THE UNIVERSITY OF ALBERTA

EYE MOVEMENTS OF NORMAL AND EDUCABLE MENTALLY RETARDED CHILDREN DURING DISCRIMINATION SHIFT LEARNING

By

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Eye Movements of Normal and Educable Mentally Retarded Children During Discrimination Shift Learning submitted by Carolyn Rose Yewchuk in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

According to the Zeaman and House (1963) attention theory, the essential mechanism underlying discrimination shift learning is the attending response. It is suggested that individual differences in learning discrimination tasks are attributable to an attention deficit. Nevertheless, the performance of slow learners on a subsequent positive transfer task is generally improved. This improvement is attributed to high probability of attending to the relevant dimension when transfer is initiated.

In the present study the performance of nine- to twelve-year-old normal children (Ns) and educable mentally retarded children (Rs) was compared in Slamecka's (1968) total change discrimination shift paradigm. Instrumental response variables were used to infer covert dimensional identification attending response while eye movement variables were used to ascertain overt observing response aspects of attending response. When trial of last error and percentage of learners were used as the dependent variable, as in the Zeaman and House studies, evidence was found for (a) retardate attention deficit (but only in a difficult task), (b) transfer of attending response, and (c) elimination of retardate deficit in ID shift. It was thus concluded that within a covert, dimensional identification interpretation, the assumptions and predictions of Zeaman and House theory appear justified. Nevertheless, since attending response is both inferred from, and explained by, the instrumental response measure in this instance, attention theory still remains subject to the charge of circularity levelled by Mostofsky (1968).

In order to meet this charge, corneally reflected eye movements of subjects engaged in the discrimination shift learning task were

photographed (Mackworth, 1967). Using the number of frames spent looking at the relevant and irrelevant dimensions during the first three seconds of information processing as dependent variables, it was found that:

(a) Rs looked at the relevant and irrelevant dimensions on as many frames as Ns in the original task. Thus, no independent evidence was found for an initial retardate attention deficit.

(b) There appears to be some qualified evidence that subjects looked more at the relevant dimension and less at the irrelevant dimension in ID shift as compared with ED shift. Thus, there may have been transfer of positive and/or negative observing response.

(c) Rs looked at the relevant dimension on more frames than Ns in ID shift. Although Rs exhibited an increase in attending to the relevant dimension relative to Ns when compared on the original task, this increase was not in accordance with the prediction of attention theory.

With the qualified exception of attending response transfer, then, the general conclusion reached was that no independent evidence was found in support of Zeaman and House attention theory as measured by eye movements. While the attempt to validate attention theory was largely unsuccessful, important differences in the overt attending behavior of Ns and Rs were found: Rs had consistently more unscorable eye movement frames than Ns; Rs had more selective eye-shifts in OL and ID shift than Ns; and Ns had consistently more frames on center than Rs. It is suggested that these major differences in the observing responses of Ns and Rs, as measured by eye movements, may reflect different ways of information processing by Ns and Rs.

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CHAPTER 1

INTRODUCTION

The importance of attention in discrimination learning has been debated by various theorists, from different points of view, since the 1930's. In the non-continuity versus continuity controversy, Krechevsky (1938) claimed that an animal learned only when it began to "pay attention" to the relevant stimuli, while Spence (1940) suggested that "receptor-orienting acts" were necessary in order to expose the organism's sense receptors to the relevant stimuli. In both formulations, a selection process was postulated, Krechevsky's being implicit, covert, and mediational, but Spence's being overt and objectively observable.

By making the presentation of discrimination task stimuli contingent upon an instrumental response such as pedal press, Wyckoff (1952) confirmed the role of orienting behavior, or "observing response" in discrimination learning. He showed that some overt change was necessary in the subject's receptors in order for the stimuli to be received as sensory input. For Goodwin and Lawrence (1955), however, orienting behavior comprised identification of the relevant stimulus dimension, and was overt only when spatially separate dimensions were involved. Otherwise, the orienting response was considered to occur after the reception of the stimuli by the subject.

Both overt observing responses and implicit dimension identification responses appear to be included in the Zeaman and House (1963) model of discrimination learning, under the guise of "attending". According to the model, in order to acquire a discrimination, a subject

must first learn to attend to the relevant stimulus dimension. This means that after appropriate receptor orientation has occurred, the relevant dimension may be identified. Once that dimension is attended to, then the positive and negative cues become available for instrumental response choice. The model further suggests that differences in discrimination performance among individuals are attributable to differences in attending strategies. Hence, retarded children are said to be slower in learning a discrimination than normal children because they take longer to attend to the relevant dimension. In that a measure of attending response independent of learning performance has not been used by Zeaman and House, criticisms of circular deductions have been levelled against attention theory (Mostofsky, 1968; Wischner, 1967).

One method of providing such an independent measure of what is being observed in a visual discrimination task utilizes eye movements. Unlike Wyckoff's pedal press, eye movements are a natural aspect of the observing response. They are overt, and if reliably photographed, can be recorded and measured. White and Plum (1964) found eye movements to be a more direct indication of orienting practices than extraneous responses such as sliding doors. Movements of the eye, however, can be elicited in conjunction with the various other components of the orienting or "what-is-it" reflex by novel stimuli (Lynn, 1966). A discrimination shift design which controls for such novelty effects, and thereby appears appropriate for investigating eye fixations in discrimination learning, is Slamecka's (1968) total change design.

In the total change design, since new cues appear on all dimen-

sions for the shift problem, dimensional attending can be assessed without the confounding effects of instrumental response transfer or involuntary orienting to novel features present in other designs. Because of this, the design appears particularly useful for investigating attending response in the Zeaman and House model.

By using trial of last error and percentage of learners on the one hand and eye movements on the other hand as dependent variables, the implicit dimensional identification and overt observing response components, respectively, of attending response can be isolated and investigated. Additionally, eye movement measures may provide an objective way of investigating attention theory. In that Zeaman and House have not separated dimensional identification from observing response in their model, predictions concerning the performance of subjects in both original and shift problems must be made from the same assumptions for both components.

According to attention theory, retarded children do not learn as well as normal children because of an attention deficit. At a time when increasing urbanization and mechanization necessitate the acquisition of more specialized vocational skills and more complex life styles, inability to learn is a crucial societal handicap. In order that this handicap may be counteracted, it is necessary that the learning inadequacies of retarded children be isolated and studied.

The purpose of this study, then, was to investigate attending responses of normal and educable mentally retarded children in discrimination shift learning.

CHAPTER 2

REVIEW OF THE LITERATURE

The human nervous system has a limited size, and consequently a limited capacity for processing information. Somehow redundant or irrelevant information must be discarded or ignored, so that important information might be stored. Since individuals cannot respond to all features of the stimulus input, a distinction must be made between the total stimuli impinging on a subject in any given situation, and the effective stimulus which controls the individual's behavior in that situation. Different explanations of the stimulus selection process are offered by different theoretical models. Two theories bear the greatest relevance to the present study: observing response theory, and Zeaman and House attention theory.

Observing Response Theory

The S - R theorists have assumed an external selective mechanism -- the observing response. Spence (1936) noted that the mere presence of the stimulus in the experimental situation did not assure its perception by the animal at the moment of response. In fact, solution of a discrimination problem involved learning to orient and fixate the head and eyes toward the critical stimuli. That is, the animal learned to "look at" one aspect of the situation rather than another (1937, p.432). If the animal fixated aspects of the stimulus complex which were not critical to the discrimination, it could not learn the task.

A very similar account of the observing response in discrimination

learning has been proposed by Wyckoff (1952). Using the Skinner-box, he required pigeons to execute a chain of two responses: stepping on a pedal (thereby exposing the stimuli) and pecking at the correct stimulus. In this way, the presentation of the discriminative stimuli was made contingent upon the occurrence of a pedal press. This pedal response Wyckoff called an "observing response", which was defined as "any response which results in exposure to the pair of discriminative stimuli involved" (1952, p.431). By making the observing response overt and measurable, Wyckoff laid the groundwork for subsequent investigations employing behavioral components of the selective process such as eye movements.

Mackintosh (1965) expressed strong reservations about the applicability of Wyckoff's observing response theory to discrimination learning, on the grounds that the pedal press does not affect the orientation of an animal's receptors at all, and that such receptor orientation is not necessary in the automatic perception of relevant stimuli in normal discrimination learning experiments. To this Kendler and Kendler (1966) replied that even though stimulus configurations such as black horizontal and white vertical rectangles can be seen at the same time, different eye fixations could be associated with different dimensions. When observing brightness, for instance, eye fixations might be concentrated on the central regions of the rectangles, whereas when observing shape, eye fixations might be on the rectangle outlines. If such eye fixations could be measured, and differences found, then observing response interpretations of discrimination data would be justified (1966, p.284).

Zeaman and House Attention Theory

Zeaman and House (1963), in extending the above theoretical views, proposed that in acquiring a discrimination a subject has to learn a chain of two responses. The first involves attending to the relevant stimulus dimension; the second involves instrumental responding to the positive cue on that dimension. Zeaman and House contend that subjects do not differ in learning which cue to respond to, but they do vary considerably in length of time prior to observing the relevant dimension. Subjects who are slow to learn discrimination tasks are said to be deficient in dimensional attending responses. In order to probe deficiencies in discrimination learning, it is thus considered necessary to investigate attending responses.

In the Zeaman and House theory, as originally proposed, the nature of attending responses is somewhat ambiguous. On the one hand, reference is made to observing responses which are subject to "the same laws, such as acquisition and extinction, as any other response" (1963, p.214), and direct indebtedness is acknowledged to Wyckoff (1952) who "defines the observing response as any response which results in exposure to the relevant cues" (1963, p.216). From this it would appear that by "attending response" Zeaman and House mean nothing more than overt, objectively measurable responses of the organism to stimuli. This interpretation of attending response appears to have been taken by others. For instance, Kendler and Kendler (1968) consider that overt response is the essence of Zeaman and House's theory. Using S - R

language, they represent attention theory as $S_1 - R_1 \rightarrow s_2 - R_2$, where,

> the subject orients (R_1) his receptors to a certain portion of the environment (S_1), and as a result, his receptors are presumably exposed to a component (s_2) of the stimulus pattern (S_1).
>
> (1968, p.222)

On the other hand, Zeaman and House refer to a "central process" (1963, p.200), and emphasize the dimensional nature of the observing response, after Goodwin and Lawrence (1955). From this perspective, overt behaviors are considered to be of incidental importance in attending. Instead, what occurs cognitively, once the stimuli have been physically oriented to, is of paramount importance. This interpretation has been taken by Reese and Lipsitt (1970) who consider attending responses to be central, selective mediating responses.

Both the observing response and the dimensional identification interpretations of attending response appear warranted, and a rejection of one or the other appears to be premature. In fact, it seems reasonable to assume that both aspects of attending response are involved in discrimination learning.

Nevertheless, Zeaman and House theory has been criticized for circularity of reasoning. Mostofsky (1968) has suggested that since an objective measure of attending (one that is independent of acquisition measures) has not been employed in the reported studies, the deficit

in attending strategies has been both explained by, and inferred from, instrumental response performance. The failure to select an operational measure of attending has resulted in the argument that subjects are deficient in attending strategies (that is, they are slow to learn discrimination tasks) because they already have a deficit in attending (Wischner, 1967). What is needed to break this circular argument is an operational definition of attending response that is independent of overt response choice.

Such an operational definition has been attempted by Muir (1971) to explore retardate attentional deficiency. In the Muir study, attention was defined in the Wyckoff observing response tradition as "looking behavior", and was assessed by quantifying various eye movements as subjects solved a discrimination learning task.

Eye movement variables would appear to provide a useful measure of observing response in a discrimination shift paradigm as well. Accordingly in this study, eye movements were recorded while subjects were engaged in a typical discrimination shift task. In this way, an independent measure of attending response was provided which could be used to furnish objective insight into Zeaman and House attention theory.

Discrimination Learning in Retarded Children

The Zeaman and House model arose out of work with moderately retarded children on two-choice, simultaneous visual discrimination learning problems. It was observed that, as with other children, retardate discrimination learning involves a chain of at least two responses, one

attentional (to the dimension) and the other instrumental (to the positive cue). Retardates, however, were said to have a low initial probability of attending to the relevant dimension, as backward learning curves are interpreted to indicate.

On these curves, differences between groups are found only with respect to the length of the initial chance portion. There are no appreciable differences in the rates at which the curves rise. In Zeaman and House's view, the length of the chance portion indicates the length of time it takes subjects to attend to the relevant dimension, while the slope of the rising portion indicates the rate at which they learn to respond to the positive cue. The crucial aspect in learning discrimination tasks, then, is not in responding to the positive cue, but rather in attending to the relevant dimension. Retardate children, because of their long initial chance performance, appear to be deficient in attention (Zeaman, 1965; Zeaman and House, 1963, 1967). The nature of attention deficiency is not clear, as was discussed in the preceding section, although retardates have been found to differ from normals in looking at the relevant dimension in a discrimination learning task (Muir, 1971).

Although it is generally accepted that retarded children have greater difficulty in learning discrimination tasks than normal children of comparable chronological age, the situation with respect to learning ability of retarded and normal children of comparable mental age is not unequivocal. Stevenson (1963) reviews eight studies to find normal children learning two-choice visual discriminations more quickly than

retardates in three studies, but no differences in learning rate in five studies. Zeaman and House (1967) list eighteen studies relating I.Q. to learning, with mental age controlled. Of these, nine reported better performances from the higher I.Q. subjects (positive results), six reported no reliable differences among I.Q. groups (negative results), and three reported both positive and negative results for different comparisons.

The basis of such divergent findings is not clear, since the studies differed on many variables, including level of problem difficulty, type of stimuli, type of reinforcement, and mode of stimulus presentation. Zeaman and House (1967), however, firmly dismiss most of the negative results on the grounds that the discrimination tasks involved were either too easy or too difficult. The remaining positive results are cited as evidence that retardates, even when matched on mental age with normal subjects, exhibit an attention deficit.

If Zeaman and House are right, then an investigation of the attention hypothesis, that retardates have a low initial probability of attending to the relevant dimension, could use normal and retarded subjects of comparable mental age. On the other hand, since not everyone accepts that normals and retardates of matched mental age differ in discrimination learning, for example, Stevenson (1963) and Wischner (1967), and furthermore since there is no control of biological maturation in mental age matches (Baumeister, 1967), it appears that a chronological age match might enable a reliable test of the attention hypothesis.

Discrimination Shift Learning

When a subject has learned a discrimination task to a stipulated criterion, he or she may then be presented with another discrimination task, usually without forewarning, in which the cue-response associations which were reinforced in the original task are changed or shifted. This combination of original learning (OL) and shift learning (SL) tasks is known as discrimination shift learning, and provides a useful test of theoretical interpretations of discrimination learning. In view of the many versions of the shift paradigm which have arisen, only that paradigm which provides the most critical test of attention theory shall be dealt with here -- Slamecka's (1968) total change design.

In this design, the same dimensions are involved in both OL and SL, but totally new cues appear on all dimensions in SL. For example, the dimensions might be color and form, with the OL cues red-green and circle-square being replaced in SL by blue-yellow and triangle-pentagon. Because totally new cues are used, problems arising from intermittent reinforcement of irrelevant cues in OL, or novelty effects of new cues in SL, are avoided, thereby making possible a purer test of attending response transfer.

The intradimensional (ID) shift retains the same relevant dimension as OL (for example, going from form to form) while the extradimensional (ED) shift does not (for example, going from form to color). If attention to a dimension transfers, then the probability of attending to the relevant dimension should be high at the beginning of ID shift, but low at the beginning of ED shift.

While it has often been accepted that when a difference between ID and ED shifts is found, positive mediational transfer (ID shift) and negative mediational transfer (ED shift) have occurred, this may not in fact be the case. It is possible, for instance, that there may have been positive transfer for the ID shift but not negative transfer for the ED shift; conversely, there may have been negative transfer for the ED shift, but not positive transfer for the ID shift. Thus, it is suggested that in order to test explicitly for direction of mediational transfer, a control shift should be included for comparison with ID and ED shifts (Shepp and Turrisi, 1967). In a control shift (CS) totally new dimensions are introduced (for example, going from form/color to size/number). Only if the CS is learned at a rate intermediate between ID and ED shifts can it be assumed that positive transfer has occurred in ID shift while negative transfer has occurred in ED shift.

Since no dimensional transfer is considered to take place in CS, the CS is actually a new, second version of OL. It would thus be expected that predictions concerning performance on a CS task would parallel that of OL. The only difference between OL and CS might lie in the possibility that transfer of learning set (Reese and Lipsitt, 1970, p.270-278) has occurred in CS; such transfer could then be assessed by a comparison of performance in OL and CS. Superior performance in CS could be attributable to the subjects' having acquired a learning set response strategy about the discrimination task in OL not directly related to the specific dimensions involved in the task.

Since two different components, namely observing response and

dimensional identification, overt and covert responses respectively, are assumed in this study to be involved in attention theory, two different, though parallel, predictions may be made concerning ID and ED shift comparisons. If observing responses are transferred, then subjects should spend more time observing the relevant dimension at the beginning of ID shift rather than ED shift, as measured by eye movements. And, if dimensional identification is transferred, then ID shift should be learned more rapidly than ED shift, as measured by trial of last error and percentage of learners. Use of these dependent variables in a single study could provide opportunities for comparing and assessing the relative merits of observing response and dimensional identification interpretations of attending response. An independent measure such as eye movements could furnish objective evidence bearing on the assumptions involved in attention theory.

The dimensional nature of SL transfer has been subject to considerably more investigation than observing response. There is a sizable body of research indicating that ID shifts are consistently learned faster than ED shifts, both with normal and retarded children (Eimas, 1966; Shepp and Turrisi, 1967; Wolff, 1967; Campione, 1969; and Reese and Lipsitt, 1970). These findings would appear supportive of the view that dimensional transfer occurs in SL. Whether observing response transfer occurs as well in this paradigm does not appear to have been investigated elsewhere. Photographing eye movements at the beginning of ID and ED shifts when the probability of observing the relevant dimension is considered to be high and low, respectively, was undertaken

in this study in order to provide some empirical data in an otherwise neglected aspect of attention theory.

Normal and Retardate Comparisons in Shift Learning

Some clarification appears necessary with respect to comparative performances of normal and retarded subjects in SL. From attention theory, it would be supposed that once discrimination learning had occurred, then irrespective of the mental abilities or other qualities of the subjects, there should be no group differences in attending to the relevant dimension on ID shifts. Such homogeneity of performance could not necessarily be inferred for ED shifts, however, because learning would depend on the probability of attending to the newly relevant dimension. There is no way of deriving this probability from OL with any certitude for either normals or retardates.

Nevertheless, Zeaman and House (1963) suggest that normals differ from retardates in being more selective with respect to attending to the irrelevant dimensions in a discrimination task. While retardates are held to attend almost equally to all of the irrelevant dimensions, normals are held to concentrate on those few which, from past experience, they know to be important. Since learning the ED shift discrimination is accelerated if there is a high probability of attending to the irrelevant dimension in OL, it is assumed that normals, because of their selective attending strategies, should perform better than retardates in ED shift.

Contrary to expectation, the literature reveals considerable in-

consistency concerning normal and retardate performance on ID shifts. Of seventeen comparisons catalogued by Wolff (1967), eight found normals to be superior to retardates, two found retardates to be superior, and seven found no differences. These studies varied, however, in type of shift paradigm, number and type of irrelevant dimensions, presence of novel cues, and learning criterion, making it difficult to draw a definite conclusion concerning the relative abilities of normal and retarded subjects to learn ID shifts.

Diverse results are also found on ED shift comparisons. In nine studies reviewed by Wolff (1967), normals learned faster than retardates in two, retardates learned faster in one, and no differences were found in six. Nevertheless, for the same reasons as cited in the ID shift comparisons, it is difficult to draw conclusions concerning the relationship between intelligence and ease of learning ED shifts.

One approach to clarifying the comparative SL performance of normals and retardates which has not been considered elsewhere, as far as is known, involves comparing observing responses for the two groups. Differences in eye movements of normal and retarded children have been found in discrimination learning tasks by Muir (1971). It is conceivable that such differences exist in SL as well, with a possible effect on the relative performance of normals and retardates. Measurement of observing responses in this study was undertaken in an attempt to resolve this issue.

Eye Movements in Discrimination Learning Studies

Previous investigations of the observing response in discrimination learning have involved such overt behaviors as pedal press (Wyckoff, 1952), eye movements (Muir, 1971; Scott and Christy, 1968; and White and Plum, 1964), button press (Eimas, 1969), and finger touch (Rydberg, 1969; Rydberg and Arnberg, 1969a, 1969b; and Rydberg, Kashdan and Trabasso, 1966). Of these the most direct and meaningful measure of a subject's orienting activity in a visual discrimination task appears to be eye movements, although such studies are relatively few in number.

Among these few, White and Plum (1964) photographed the eye movements of thirty-one nursery school children as they learned a series of easy discriminations between bird pictures, and a series of hard discriminations between stick figures. Using general shifts of fixation from the right to the left side of the stimulus field or vice-versa, as the dependent variable, White and Plum found easy discriminations productive of more eye movements than hard discriminations. It was suggested that perhaps this was attributable to bird pictures being more interesting and distinctive to look at than stick figures, and consequently easier to discriminate. In both series, however, there was a rise in fixation shifts as the onset of criterion approached, and a decline thereafter. It was pointed out that since the results did not approach significance, the conclusions reached were necessarily tentative.

In another study, Scott and Christy (1968) compared experimenter-recorded eye-shifts of twenty-five nursery school children on a two-

choice visual discrimination. For both learners and non-learners, a marked decrease in eye scans after the first trial was found for both groups. In that learners reached criterion on the second trial, decrease in eye-shifts was considered to reflect the White and Plum findings. The decrease in eye-shifts for non-learners, however, was attributed by Scott and Christy either to pseudo-solutions such as position bias, or to a general habituation process as the novelty of the problem decreased through repeated presentations.

Several other eye movement measures in addition to shifts have been recorded by Muir (1971) in a recent study comparing normal and educable mentally retarded children matched on chronological age. A two-choice visual simultaneous discrimination task was used to explore the attentional deficit in retarded children postulated by Zeaman and House (1963). In keeping with the assumption that normals have the greater initial tendency to attend to the relevant dimension than retardates, Muir analyzed percentage of frames on relevant cues. The assumption appeared valid, in that normals were found to differ from retardates in having more frames on relevant cues. Since retardates are considered to be more easily distractible generally and, hence, more likely to exhibit gross eye, head, or body movements which might interfere with eye movement recording, an eye movement measure involving percentage of unscorable frames was also used as an indication of attention deficit in the Muir study. It was confirmed that there were more unscorable frames for retardates than for normals.

Blackhurst and Radke (1966) in another kind of study found retarded children to have difficulty generally in fixating objects and controlling observing responses. The unscorable frames variable might therefore distinguish normal and retardate performance, irrespective of the situation involved, unlike the other eye movement variables.

From these studies it appeared that shifts, frames on relevant cues, frames on irrelevant cues, and unscorable frames might be useful eye movement measures of attending response in a discrimination shift task.

Summary

The various studies bearing on discrimination learning presented here suggest that comparisons within a total change discrimination shift design (Slamecka, 1968) should provide interesting opportunities for assessing overt observing response and implicit dimensional identification aspects of Zeaman and House's (1963) attention theory. While the dimensional identification (central covert attentional response) aspect has been subject to considerable investigation using measures such as trials to criterion, the observing response aspect of discrimination learning has been relatively neglected. With the recent development of sophisticated photographic techniques, however, it appears that eye movement variables may provide a valuable measure of observing response. Also, eye movements may provide the kind of objective measures which until now attention theory has been considered to lack. Furthermore, such a study may also help clarify some discrepant findings concerning

ED shift performance, and normal versus educable mentally retarded children's performance in SL.

In this investigation it was thus proposed to obtain concurrent measures of observing response and dimension identification aspects of discrimination shift learning by normal and educable mentally retarded subjects.

CHAPTER 3

RATIONALE, DEFINITIONS AND HYPOTHESES

Rationale

Discrimination learning in the Zeaman and House (1963) model consists of two chained responses, one attentional to the relevant dimension, and the other instrumental to one of the cues exposed on that dimension. The important response is the dimensional attending response, for it is a deficiency in this area that is considered to characterize poor performance in discrimination problems, thus accounting for individual differences as sometimes found between normal and retarded subjects. The nature of the dimensional attending response, however, is not very clear. On the one hand, an observing response interpretation dwells on exposure of the stimuli to the subject's receptors (for example, Kendler and Kendler, 1966), while on the other, a central mediational process interpretation dwells upon the actual identification of stimulus dimensions (for example, Reese and Lipsitt, 1970). It appears that both interpretations may be valid, and the exclusion of one or the other from attention theory may be premature.

Moreover, with the recent development of sophisticated photographic equipment and techniques (see Mackworth, 1967), it is now possible to arrive at direct measures of visual observing responses by recording the movements of the eyes. The eye movements of normal and retarded children engaged in discrimination tasks have already been shown to differ in terms of frames on relevant dimensions, frames on irrelevant dimensions, and unscorable frames (Muir, 1971), and shifts (Scott and

Christy, 1968; and White and Plum, 1964). Such eye movements, if obtained concurrently with measures that have been used in the past to infer dimensional identification processes (for example, trial of last error), might be expected to provide the basis for comparing the two different interpretations of attention theory. In addition, work with various shift designs has resulted in a paradigm in which attentional transfer may be compared without instrumental response or novel cue interference (Shepp and Turrisi, 1967; and Slamecka, 1968).

Consequently, it seems feasible that observing response interpretations of attention theory could be investigated using eye movement measures. Additionally, comparisons between observing response (eye movements) and dimensional identification (trial of last error and percentage of learners) interpretations may be attempted. More specifically, it is intended to apply the assumptions of attention theory to both observing response and dimensional identification, in both original learning and shift learning tasks, with both normal and retarded children.

Definitions

General Terms

<u>eye movements</u>: the recorded movements of a subject's eyes while scanning discrimination task stimuli.

<u>frame</u>: a single exposure of 16 mm. movie film, for one-tenth of a second, normally comprising a corneal reflection superimposed on an image of the discrimination task stimuli.

first thirty frames: the first thirty frames of eye movement data during a trial, recorded at the rate of ten frames per second. This represents the initial three seconds of eye movement recording during each stimulus presentation.

learning criterion: a series of nine consecutive correct responses to the discrimination task.

original learning task (OL): the first discrimination task presented to the subject, comprising a maximum of thirty trials.

shift learning task (SL): the discrimination task, comprising a maximum of thirty trials, presented to the subject immediately upon reaching criterion on the original learning task.

intradimensional (ID) shift: positive discrimination transfer task, where the same dimension is relevant in the shift learning task as in the original learning task.

extradimensional (ED) shift: negative discrimination transfer task, where the relevant dimension in the shift learning task consists of the dimension which was irrelevant in the original learning task.

control shift (CS): a discrimination transfer task neither positive nor negative, where a dimension not appearing in the original learning task is relevant to solution in the shift learning task.

central figures (CF) dimension: the discrimination task stimuli, comprising closed geometric figures appearing in the center of the "boxes", namely square and circle for the original learning

task, and triangle and hexagon for the shift learning task.

CF condition: the discrimination tasks wherein central figures formed the relevant dimension in original learning. This classification was maintained even when the relevant dimension was changed in shift learning to Dots as in the extradimensional shift.

Dots dimension: the discrimination task stimuli comprising location of dots in peripheral areas of the "boxes", namely upper left and lower right corners for the original learning task, and lower left and upper right corners for the shift learning task.

Dots condition: the discrimination tasks wherein Dots formed the relevant dimension in original learning. This classification was maintained even when the relevant dimension was changed in shift learning as in the extradimensional shift.

total subjects: all of the subjects involved in the study, n = 160.

total filmed subjects: all of the subjects for whom eye movements were obtained, n = 128. No eye movements were recorded for the thirty-two control shift subjects.

OL learners: total subjects who reached criterion in the original learning task, n = 110.

OL filmed learners: those subjects for whom eye movements were obtained who reached criterion in the original learning task, n = 89. The twenty-one control shift subjects who learned the

original learning task are excluded here.

Dependent Variables

There were two different categories of dependent variables: those derived from the subjects' instrumental response choices, and those derived from the subjects' recorded eye movements.

(1) Instrumental Response Variables:

trial of last error: For subjects who reached criterion in either original learning or shift learning tasks, the error preceding the run of nine consecutive correct responses was designated the trial of last error. Thus, for learners, the trial of last error varied from 0 to 21. Those subjects who did not learn the discrimination were arbitrarily assigned a trial of last error of 30.

percentage of learners: the percentage of subjects reaching criterion in a particular cell.

(2) Eye Movement Variables:

These variables were based on the first thirty frames (three seconds) of each trial, and were summed over the first eight trials of original learning, and the first eight trials of shift learning for each subject. The manner in which each variable was derived is indicated below. (The scoring code is listed in Appendix C.)

frames on relevant dimension: the total number of frames wherein the subject looked at either of the two cues in the

relevant dimension. For each of original and shift learning tasks, the possible range was from 0 to 240 (8 x 30).

frames on irrelevant dimension: the total number of frames wherein the subject looked at either of the two cues in the irrelevant dimension. The possible range was from 0 to 240 (8 x 30) for each of the original and shift tasks.

unscorable frames: the total number of frames which could not be scored because the eye spot was not visible or was blurred. The possible range of scores was from 0 to 240 (8 x 30) for each task.

total shifts: the number of times the corneal reflection moved from any one coded part of the stimulus field to any other, leaving out unscorable frames. The range was a function of the eye shift activity of each individual.

left-right shifts: the number of times the corneal reflection moved from any point in one stimulus "box" to any point in the other stimulus "box", leaving out unscorable frames and fixations on the center. The range was a function of the eye shift activity of each individual.

Hypotheses for Performance Data

I. Comparison of N and R Performance in OL

According to Zeaman and House (1963, 1967) Ns have a greater probability of attending to the relevant dimension initially than Rs.

Ns are said to perform better than Rs on discrimination learning tasks because of this retardate attention deficit. On the basis of this observation, the following hypotheses are proposed:

<u>Hypothesis 1.1</u>: Based on the total subjects, the mean trial of last error will be lower for Ns than for Rs in OL ($n = 80$ Ns and 80 Rs).

<u>Hypothesis 1.2</u>: Based on the total subjects, the percentage of learners in OL will be higher for Ns than for Rs ($n = 80$ Ns and 80 Rs).

II. <u>Comparison of Performance in ID Shift, ED Shift and CS</u>

According to Zeaman and House theory, attending to the relevant dimension precedes learning, and hence if learning has occurred, the probability of attending to the relevant dimension must be high. Furthermore, attending responses are said to be capable of transfer. An ID shift reflects positive attending response transfer, while an ED shift reflects negative attending response transfer. In CS, with the introduction of totally new dimensions, neither positive nor negative dimensional transfer is involved. It would be anticipated that for OL learners, ID shift would be learned more easily than either CS or ED shift, while CS would be easier than ED shift. On the basis of these considerations, the following hypotheses are proposed:

<u>Hypothesis 2.1</u>: For OL learners, the mean trial of last error in SL will be ordered such that ID shift $<$ CS $<$ ED shift ($n = 48$, 21, and 41 per cell, respectively).

Hypothesis 2.2: For OL learners, the percentage of learners in SL will be ordered such that ID shift > CS > ED shift (n = 48, 21, and 41 per cell, respectively).

III. Comparison of N and R Performance in ID Shift, ED Shift and CS

It is assumed that once Rs have learned the OL task, the probability of attending to the relevant dimension is at asymptote as for the N subjects who have learned the task. Consequently, when considering transfer to ID shift, no difference would be expected in the performance of Ns and Rs. At the commencement of ID shift, Rs are assumed to be as likely to observe the relevant dimension as Ns.

In ED shift, subjects are faced with a situation where the previously relevant dimension is now irrelevant to solution. In this new learning situation, speed of learning is a function of the probability of observing the previously irrelevant dimension. According to Zeaman and House, learning the ED shift is accelerated if the attending response probabilities to the previously irrelevant dimensions in OL are greater for some dimensions than for others, rather than being nearly equal for all the irrelevant dimensions in OL. It is additionally assumed that Ns are more likely to react to the important dimensions than Rs, thereby being more likely to have differential attending response probabilities than Rs for the previously irrelevant dimensions. From this position, it would appear that Ns should perform better than Rs on ED shift.

Since CS introduces totally new dimensions, the same differences which emerge between Ns and Rs in OL might be expected to emerge in CS.

Based on these considerations, the following hypotheses are proposed:

<u>ID Shift</u>

<u>Hypothesis 3.1</u>: For OL learners, there will be no difference between Ns and Rs in mean trial of last error in ID shift (n = 28 Ns and 20 Rs).

<u>Hypothesis 3.2</u>: For OL learners, there will be no difference in the percentage of N and R learners in ID shift (n = 28 Ns and 20 Rs).

<u>ED Shift</u>

<u>Hypothesis 3.3</u>: For OL learners, Ns will have a lower mean trial of last error than Rs in ED shift (n = 26 Ns and 15 Rs).

<u>Hypothesis 3.4</u>: For OL learners, a higher percentage of Ns than Rs will learn ED shift (n = 26 Ns and 15 Rs).

<u>Control Shift</u>

<u>Hypothesis 3.5</u>: For OL learners, Ns will have a lower mean trial of last error than Rs on CS (n = 15 Ns and 6 Rs).

<u>Hypothesis 3.6</u>: For OL learners, a higher percentage of Ns than Rs will learn CS (n = 15 Ns and 6 Rs).

<u>Hypotheses for Eye Movement Data</u>

I. <u>Comparison of Eye Movement Patterns of Ns and Rs in OL</u>

Muir (1971) has found that Ns looked more at the relevant dimension than Rs while learning a discrimination task. This finding appears to be consistent with the Zeaman and House assumption that Ns have a

higher initial probability of attending to the relevant dimension in OL than Rs. Conversely, it is assumed that Rs have a higher initial probability of attending to the irrelevant dimension than Ns, and hence might be expected to look more at the irrelevant dimension in OL than Ns. Furthermore, Muir (1971) found that Ns had fewer unscorable frames than Rs in OL. Since the collection of eye movement data requires that gross head and eye movements be kept at a minimum, this finding appears to reflect the general consensus that Ns are better able to concentrate on tasks at hand, and are less distracted by competing stimuli, than Rs. On the basis of these considerations, the following hypotheses are proposed:

<u>Hypothesis 4.1</u>: For the total filmed samples, Ns will have more frames on relevant dimension than Rs in OL (n = 64 Ns and 64 Rs).

<u>Hypothesis 4.2</u>: For the total filmed samples, Ns will have fewer frames on irrelevant dimension than Rs in OL (n = 64 Ns and 64 Rs).

<u>Hypothesis 4.3</u>: For the total filmed samples, Ns will have fewer unscorable frames than Rs in OL (n = 64 Ns and 64 Rs).

II. <u>Comparison of Eye Movement Patterns in ID and ED Shifts</u>

While there appears to be no direct evidence of eye movement transfer in a discrimination shift paradigm, it is assumed that certain eye movement patterns may be subject to the kinds of transfer specified by Zeaman and House theory. In particular, the eye movement measures of frames on relevant and irrelevant dimensions may reflect the attending responses to the relevant and irrelevant dimensions, respectively.

Accordingly, since the relevant dimension remains unchanged in ID shift, but changes in ED shift, there should be more looking at the relevant dimension in ID shift than ED shift. On the other hand, the opposite should hold for the irrelevant dimension in SL; there should be more looking at the irrelevant dimension in ED shift than in ID shift. On the basis of these considerations, the following hypotheses are proposed:

Hypothesis 5.1: For filmed OL learners, there will be more frames on relevant dimension in ID shift than ED shift (n = 48 in ID and 41 in ED).

Hypothesis 5.2: For filmed OL learners, there will be fewer frames on irrelevant dimension in ID shift than ED shift (n = 48 in ID and 41 in ED).

III. Comparison of Eye Movement Patterns of Ns and Rs in ID Shift and ED Shift

Once Rs have learned the OL task, it is assumed that the probability of attending to the relevant dimension will be at asymptote similar to that of the Ns who have learned the OL task. Consequently, since the same dimension is relevant on ID Shift, no difference would be anticipated between Ns and Rs in observing the relevant dimension. The probability of attending to the irrelevant dimension would be minimal at the termination of the OL task for both Ns and Rs and would remain so in ID shift. No difference would be expected between Ns and Rs in observing the irrelevant dimension in ID shift.

In ED shift, because the previously irrelevant dimension now becomes relevant, subjects must switch their attention to this previously

irrelevant dimension to attain the solution. However, Zeaman and House (1963) have suggested that at the termination of OL, the distribution of the observing response probabilities for Rs is even, whereas this distribution is unequal for Ns. That is, the more salient or important dimensions have slightly higher probabilities of being observed for Ns. The Ns should thereby switch to these dimensions more rapidly on ED shift than Rs. Thus, Rs should look more at the irrelevant dimension and less at the relevant dimension in ED shift than Ns.

Since the unscorable frames variable appears to reflect processes not directly related to attending response as defined in the current study, no transfer effects could be anticipated in either the ID or ED shift conditions. Consequently, in both ID and ED shifts, Ns would have fewer unscorable frames than Rs, as in OL.

On the basis of these considerations, the following hypotheses are proposed:

<u>ID Shift</u>

<u>Hypothesis 6.1</u>: For filmed OL learners, there will be no difference between Ns and Rs in frames on relevant dimension in ID shift (n = 28 Ns and 20 Rs).

<u>Hypothesis 6.2</u>: For filmed OL learners, there will be no difference between Ns and Rs in frames on irrelevant dimension in ID shift (n = 28 Ns and 20 Rs).

<u>Hypothesis 6.3</u>: For filmed OL learners, there will be fewer unscorable frames for Ns than for Rs in ID shift (n = 28 Ns and 20 Rs).

ED Shift

Hypothesis 6.4: For filmed OL learners, Ns will have more frames on relevant dimension than Rs in ED shift (n = 26 Ns and 15 Rs).

Hypothesis 6.5: For filmed OL learners, Ns will have fewer frames on irrelevant dimension than Rs in ED shift (n = 26 Ns and 15 Rs).

Hypothesis 6.6: For filmed OL learners, there will be fewer unscorable frames for Ns than for Rs in ED shift (n = 26 Ns and 15 Rs).

IV. Comparison of Eye-shift Activity

There has been some investigation of eye-shifts during discrimination learning by Scott and Christy (1968) and White and Plum (1964), who found gross eye-shifts from left to right or *vice-versa* to vary in normal nursery school children with onset on criterion. Muir (1971) found that on total shifts of eye fixation (that is, shifts regardless of direction or fixation of stimulus) there was no difference between normal and educable mentally retarded children. In that the eye-shift variables used in these studies (left-right shifts and total shifts) might provide some interesting exploratory data on transfer of observing responses in a shift paradigm for normal and educable mentally retarded children, the following hypotheses are proposed:

Hypothesis 7.1: For the total filmed samples, there will be no difference between Ns and Rs on total shifts and left-right shifts in OL (n = 64 Ns and 64 Rs).

<u>Hypothesis 7.2</u>: For filmed OL learners, there will be no difference on total shifts and left-right shifts in ID and ED shifts (n = 48 in ID and 41 in ED).

<u>Hypothesis 7.3</u>: For filmed OL learners, there will be no difference between Ns and Rs on total shifts and left-right shifts in ID shift (n = 28 Ns and 20 Rs).

<u>Hypothesis 7.4</u>: For filmed OL learners, there will be no difference between Ns and Rs on total shifts and left-right shifts in ED shift (n = 26 Ns and 15 Rs).

CHAPTER 4

METHOD

Subjects

Two samples of subjects aged nine to twelve years were selected from the Edmonton Public School System. The first comprised educable mentally retarded children (R) whose IQ scores on the full scale of the *Wechsler Intelligence Scale for Children* (WISC) fell between fifty and eighty. Most subjects were selected from primary and junior opportunity classes in various elementary schools, while a few of the older subjects were drawn from L. Y. Cairns Vocational School. The R sample was composed of eighty children (forty boys and forty girls). In order to counterbalance chronological age (CA) and sex, there were twenty children (ten boys and ten girls) who were nine, ten, eleven and twelve years old. The nine- and ten-year-olds were labelled "young" while the eleven- and twelve-year-olds were labelled "old" for the purpose of experimental classification and analysis. The mean CA of the R sample was ten years and eleven months.

The second sample comprised normal children (N) drawn from regular grade four, five, six and seven classes, whose full scale WISC scores exceeded 100. The N sample consisted of eighty children, matched on sex and CA with the R sample (See Table 1). The mean CA of the N sample was ten years and eleven months, the same as that of the R sample. Children with known organic defects, sensory impairments, or emotional problems were excluded from the study, as were those who wore

Table 1

Age and Full Scale WISC IQ of Subjects

		Age in months			Full Scale WISC IQ		
	No.	M	sd	range	M	sd	range
Sample							
Normals (N)	80	130.5	13.0	108-154	113.9	9.3	100-138
Retardates (R)	80	131.4	13.2	109-155	71.9	5.8	55- 80
Sex							
Boys (B)	80	131.5	13.4	108-155	94.8	22.1	61-138
Girls (G)	80	130.4	12.8	109-154	91.0	22.7	55-134
Age Category							
Young (Y)	80	119.7	6.5	108-131	92.4	22.3	55-133
Old (O)	80	142.2	6.8	132-155	93.4	22.7	58-138
Experimental Group							
NBY	20	119.8	6.6	108-129	116.6	8.2	100-133
NBO	20	143.4	5.8	132-153	114.9	8.5	101-138
NGY	20	119.8	6.9	109-131	109.9	8.7	100-125
NGO	20	139.1	9.2	133-154	114.3	10.8	100-134
RBY	20	119.3	6.5	110-131	73.4	5.8	61- 80
RBO	20	143.3	5.4	132-155	74.4	4.5	63- 80
RGY	20	120.0	6.6	109-129	69.9	6.3	55- 80
RGO	20	142.9	5.7	133-153	70.1	5.5	58- 80

eye glasses or contact lenses.

The eighty subjects in each of the samples formed four experimental groups counterbalancing sex (boys and girls) and age (young and old). These groups were: young boys (BY), old boys (BO), young girls (GY), and old girls (GO). Altogether, then, there were eight experimental groups in the two samples, each comprising twenty subjects: NBY, NBO, NGY, NGO, RBY, RBO, RGY, RGO. Data on the mean ages and IQs of these groups are presented in Table 1.

Discrimination Shift Task

The original learning (OL) task consisted of a two-choice visual discrimination, with two variable dimensions, discrete in form to facilitate eye movement measurement: central figures (CF) comprising a circle and square, and peripheral dot location (Dots) in the upper left and lower right corners. For half the subjects, the CF dimension was relevant with positive cue (circle and square) counterbalanced; whereas for the other half, the location of the peripheral dots was relevant, with upper left and lower right dots counterbalanced as positive (correct) cue.

Following learning to a criterion of nine consecutive correct trials, a discrimination shift problem was presented incorporating new cues for the original dimensions (hexagon and triangle for CF and lower left and upper right for dot location). Half of the filmed subjects were given an intradimensional (ID) shift, with dimension and positive cue counterbalanced; and half, a similarly counterbalanced extradimen-

sional (ED) shift, again to the same criterion. There were thus four filmed conditions: an ID shift with CF relevant, an ID shift with Dots relevant, an ED shift from CF to Dots, and an ED shift from Dots to CF.

For subjects in the control shift (CS), two new dimensions, size (large and small) and number (three and four) were introduced with counterbalancing and criterion procedures corresponding to that of the filmed shifts. Accordingly, there were four control conditions as well. All the conditions, with counterbalancing, are presented in Table 2.

Randomization of Subjects

The eight experimental groups of subjects presented in Table 1 each consisted of twenty subjects. A table of random numbers was used to generate the numbers one to twenty, inclusive, eight times in order to have different random orderings for each of the eight experimental groups.

For convenience of slide presentation and score sheet use, the various counterbalanced tasks were coded by letter, for example, A1 (See Table 2). For ID and ED shift tasks, codes A1 through D4 were equated with the randomized numbers one through sixteen, respectively. In each of the randomized orderings previously created, the letter code was substituted for the random number. In the ID and ED shift tasks there was one subject from each of the experimental subject groups (or a total of eight subjects) for each of the sixteen counterbalanced tasks (See Table 2).

In the CS condition, however, there were only four subjects from

Table 2

Discrimination Shift Conditions

Type of Shift	Relevant Dimension OL	Relevant Dimension SL	Positive Cue OL	Positive Cue SL	No. of Ss	Codes	
ID	CF	CF	circle	hexagon	8	A1	1
			circle	triangle	8	A2	2
			square	hexagon	8	A3	3
			square	triangle	8	A4	4
ED	CF	Dots	circle	lower left	8	B1	5
			circle	upper right	8	B2	6
			square	lower left	8	B3	7
			square	upper right	8	B4	8
ID	Dots	Dots	upper left	lower left	8	C1	9
			upper left	upper right	8	C2	10
			lower right	lower left	8	C3	11
			lower right	upper right	8	C4	12
ED	Dots	CF	upper left	hexagon	8	D1	13
			upper left	triangle	8	D2	14
			lower right	hexagon	8	D3	15
			lower right	triangle	8	D4	16
CS	CF	size	circle	large	2	E1	17
			circle	small	2	E2	17
			square	large	2	E3	17
			square	small	2	E4	17
CS	CF	number	circle	three	2	F1	18
			circle	four	2	F2	18
			square	three	2	F3	18
			square	four	2	F4	18
CS	Dots	size	upper left	large	2	G1	19
			upper left	small	2	G2	19
			lower right	large	2	G3	19
			lower right	small	2	G4	19
CS	Dots	number	upper left	three	2	H1	20
			upper left	four	2	H2	20
			lower right	three	2	H3	20
			lower right	four	2	H4	20

each of the experimental subject groups remaining for the sixteen counterbalanced tasks. Accordingly, only one subject from each group (or a total of eight subjects) was available for each major shift condition (for example, CF-size: E1 to E4). The CS subjects were assigned across shift conditions so as to counterbalance intelligence, sex and age. The codes E1 through H4 were equated with the random numbers seventeen through twenty, respectively (See Table 2), and substituted in the random orderings.

As the subjects were brought to the lab, they were then simply listed, one after the other, in their respective experimental subject groups, as determined by intelligence, sex and age.

Stimulus Slides

Eight trays of slides were prepared in order that the four filmed and four control conditions could be presented without reshuffling of slides. In each of these conditions, there was a standard sequence for the correct cue across the sixty OL and shift learning (SL) trials, in accordance with a modified Gellermann (1933) procedure.

In the filmed conditions, four training slides featuring outline drawings of the sun and moon were presented first. Then the first eight OL slides were alternated with eight calibration slides, followed by the remaining twenty-two slides. In the SL task, the first eight slides were again alternated with eight calibration slides, followed by the remaining slides of the shift. For the control conditions, slide arrangements were identical, with the exception of the calibration

slides, which were omitted, since no trials of the control conditions were filmed.

The slides were prepared by photographing black and white sketches of the stimuli within outline "boxes". Examples of the slides may be seen in Figure 1.

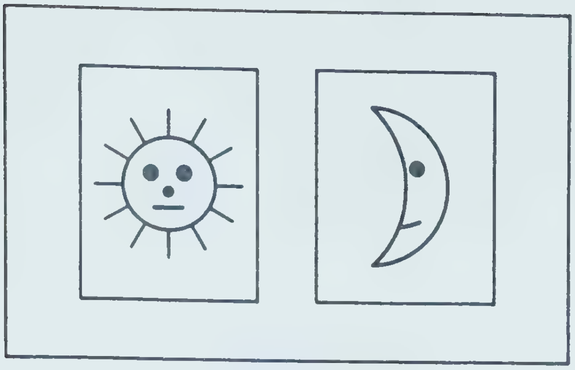
Equipment

The experiment was conducted in a small, sound attenuated, air conditioned laboratory with blackened walls in the Faculty of Education Building at the University of Alberta.

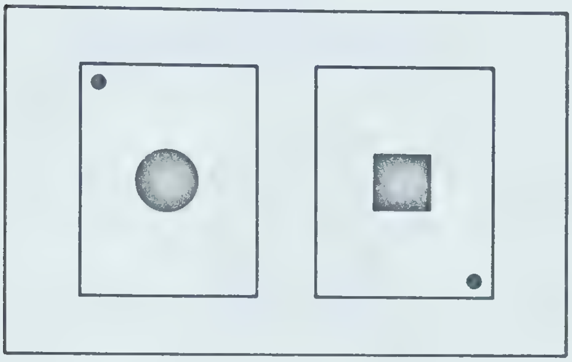
A Polymetrics Products Eye-Movement Recorder (Model V-1164) was used to obtain movie photographs of the eye movements of subjects, by superimposing a corneally reflected "eye spot" upon the experimental stimulus materials. The resultant composite images were filmed by a Pathé "professional" 16 mm. camera at a constant exposure rate of ten frames per second (See Mackworth, 1967, for full details). A schematic view of the recording procedure is presented in Figure 2.

A random access Kodak Carousel Projector (Model RA 950) was used to project 35 mm. stimulus slides onto the rear surface of a translucent screen, eight inches square. The screen was approximately twenty-six inches away from the subjects' eyes. Spring loaded pressure switches which activated low intensity lights in front of the research assistant by closing a battery-operated circuit were used to indicate subjects' stimulus choice in the discrimination shift task.

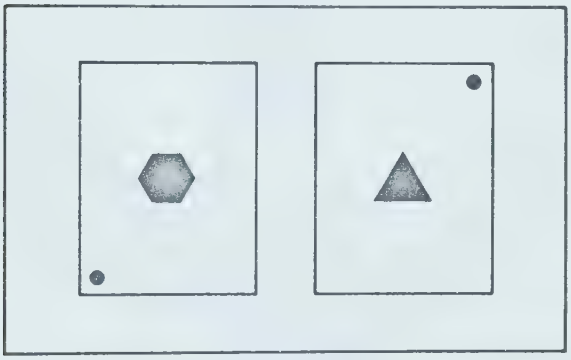
Task instructions were presented on a Sony Cassette Tape



TRAINING



ORIGINAL LEARNING TASK (OL)

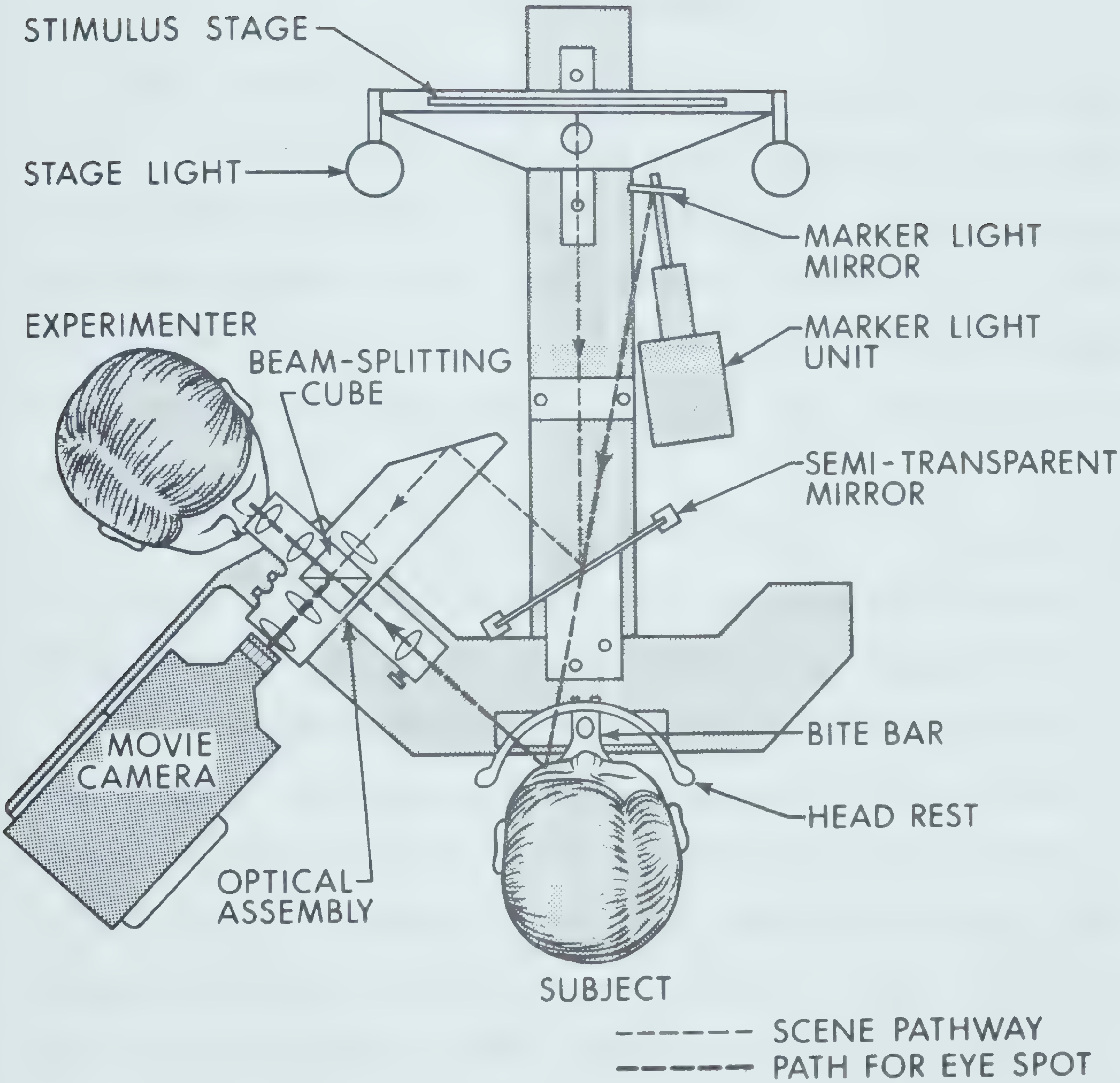


ID AND ED SHIFTS

CONTROL SHIFT

STIMULUS SLIDES FOR DISCRIMINATION SHIFT TASK

Figure 1



SCHEMATIC VIEW OF EYE MOVEMENT CAMERA

Figure 2

Recorder (Model TC 110). Eye movement recordings were scored by viewing the 16 mm. film on a Kodak Analyst Projector which provided single frame projection and stop action.

Testing Procedure

The cumulative records of subjects were examined for WISC test scores, and those subjects not tested within the previous year were given a WISC in the school by the investigator or a research assistant. One hundred percent of the Ns and twenty-two percent of the Rs were so tested. The R children scoring outside the fifty to eighty full scale WISC criterion scores were excluded from the study, as were N children scoring below 100.

Subjects were transported to the university by taxi in groups of two to four, where they were individually tested in the laboratory. After being familiarized with the apparatus in the laboratory, the filmed subjects were seated and fitted with a bite bar to minimize head movement. The subjects were then trained to indicate stimulus choice by button press, and to view the stimuli for a five-second interval before responding. Then the eye movement recorder was calibrated and the discrimination task was explained on tape (See Appendix A for detailed testing procedure and taped instructions). Control subjects followed the same familiarization and training procedure, with the exception of bite bar fitting and filming.

The stimuli were presented for five seconds, in a modified Gellermann (1933) order until the criterion of nine consecutive correct

trials was reached, whereupon the shift task was presented without announcement, again until criterion, or the maximum of thirty trials. Eye movements were recorded for the first eight trials in OL and the first eight trials in SL for the filmed subjects. The eye movement recorder was calibrated before each filmed trial. Stimulus choices were recorded on special answer sheets (See Appendix B), and the subject was told whether his choice was correct or wrong.

Subjects were given five seconds to view a slide before being asked to indicate their stimulus choice by button press in order to have a standard time base for filmed eye data comparisons. On the average, filmed subjects were tested in half an hour, while control subjects were tested in fifteen minutes. The testing time tended to be longer for Rs than for Ns, both because Rs took longer to become familiarized with the laboratory, as well as generally requiring more trial presentations in OL and SL.

Scoring of Eye Movement Data

Eye movement data were scored frame by frame using a Kodak Analyst Projector, according to the location of the corneal reflection on the stimulus field. (The numerical code used is listed in Appendix C.) Occasionally, however, as a result of head movement, blinking, or a very rapid eye movement, the corneal reflection was blurred or not visible. These frames were scored according to the guidelines laid down in Appendix C.

The fifty frames subsequent to the first noticeable eye movement were scored on each trial. The raw data score sheets used to code each frame for a particular trial, as well as the score sheets summing these data over ten-frame (one second) intervals, are found in Appendix D. In this study, only the summed data for the first thirty frames (three seconds) were analyzed.

The eye movements of three subjects were chosen at random at the completion of scoring, to provide a reliability check on the scoring procedure. A ninety-six percent agreement was found between the original and the rescored data, based on 2400 frames (fifty frames x sixteen trials x three subjects).

General Experimental Design

A two x two x three factorial experiment with sixteen and eight observations per cell was performed. The factors were, respectively, intelligence (Ns and Rs), relevant dimension (CF and Dots), and shift type (ID, ED, and CS). There was counterbalancing of the sex and age of subjects as well as of the positive (correct) stimulus for both OL and SL tasks. A schematic representation of the design appears in Table 3.

Table 3

Experimental Design

Subjects	Relevant Dimension in OL	Type of Shift
NORMALS (n = 80)	CENTRAL FIGURES (n = 40)	CS (n = 8)
		ID (n = 16)
		ED (n = 16)
	DOTS (n = 40)	CS (n = 8)
		ID (n = 16)
		ED (n = 16)
RETARDATES (n = 80)	CENTRAL FIGURES (n = 40)	CS (n = 8)
		ID (n = 16)
		ED (n = 16)
	DOTS (n = 40)	CS (n = 8)
		ID (n = 16)
		ED (n = 16)

CHAPTER 5

DISCRIMINATION SHIFT PERFORMANCE DATA

Tests for Counterbalancing

Preliminary to the investigation of the postulated hypotheses, analyses of variance were run to verify the counterbalancing of sex and age in subjects, as well as of positive and negative cues in all task conditions. These analyses were run using mean trial of last error in the original learning task as the dependent variable.

In order to test for sex and age counterbalancing in the filmed subjects (all subjects except controls, n = 128), a five-way complete factorial analysis (two x two x two x two x two) with four subjects in each cell was run. The factors were, respectively, intelligence (Ns and Rs), sex (boys and girls), age (young and old), shift (ID and ED), and relevant dimension (CF and Dots). The results indicated an effect of IQ ($F = 29.8$, $df = 1/96$, $p < .001$) and relevant dimension ($F = 60.6$, $df = 1/96$, $p < .001$), but no shift ($F = 1.2$, $df = 1/96$, $p = .276$), age ($F = 0.6$, $df = 1/96$, $p = .424$), sex ($F = 0.03$, $df = 1/96$, $p = .861$) nor interaction effects other than intelligence x dimension ($F = 9.3$, $df = 1/96$, $p = .003$). Accordingly, sex and age were assumed to be counterbalanced for the filmed subjects, and further analyses were computed after collapsing across these two variables.

Additionally, a two (intelligence) x two (sex) x two (age) analysis of variance with four subjects in each cell was performed for the thirty-two control subjects. Again the results indicated an IQ

effect ($F = 19.1$, $df = 1/24$, $p < .001$), but no age ($F = 1.8$, $df = 1/24$, $p = .196$), sex ($F = 0.003$, $df = 1/24$, $p = .959$), nor interaction effects. Sex and age were thus seen to be counterbalanced for the control subjects as well, and further analyses were collapsed over these two variables.

In order to test for counterbalancing of positive and negative cues, a one-way analysis of variance was run for all of the OL tasks in which CF were relevant, and then for those OL tasks in which Dots were relevant for the total subjects. The two dimensions were run separately because different cues were involved. The dependent variable was the mean trial of last error. From Table 2 it may be seen that ten groups each consisting of eight subjects are formed within the CF filmed and control conditions (A1, A2, A3, A4, B1, B2, B3, B4, E1-4, and F1-4), and another ten groups within the Dots conditions (C1, C2, C3, C4, D1, D2, D3, D4, G1-4, and H1-4). The one-way analysis of variance for the CF groups yielded a non-significant main effect ($F = 0.6$, $df = 9/70$, $p = .771$) as did the analysis for the Dots groups ($F = 0.4$, $df = 9/70$, $p = .942$) in terms of mean trial of last error. It appeared, then, that the effects of positive and negative cues were counterbalanced within all task conditions, and consequently could be collapsed for further analyses.

To summarize, it was concluded that the assumptions involving counterbalancing of subjects' sex and age were tenable, as were those involving counterbalancing of positive and negative cues within the various filmed and control discrimination task conditions.

Reporting of Analyses

Where homogeneity of variance permitted, two-way analyses of variance were employed, the factors being intelligence (Ns and Rs) and relevant dimension (CF and Dots), with alpha level being .05 for both directional and nondirectional hypotheses. If interaction effects were found in the analyses of variance, Scheffé tests were calculated to determine the simple main effects. Where homogeneity of variance was lacking, Welch's t' statistic was calculated (See Winer, p.37). Hypotheses involving percentage of learner data were analyzed using χ^2.

In order to simplify presentation and discussion of data, the mean trials of last error (M), standard deviations (sd) and numbers (n) of normal and educable mentally retarded subjects for each of the separate dimensions in the various shift tasks are presented in Table 4.

Results for Performance Hypotheses

I. Comparison of N and R Performance in OL

Hypothesis 1.1, that based on all subjects the mean trial of last error will be lower for Ns than for Rs in OL, was only partially supported. From Table 5, which presents data pertinent to this hypothesis, it may be seen that when CF formed the relevant dimension, no significant difference was found between Ns and Rs. In this easy condition, both groups of subjects experienced little difficulty in solving the discrimination task. Thus Hypothesis 1.1 was not supported for the CF condition.

On the other hand, when Dots were relevant to task solution in

Table 4

Mean Trials of Last Error (M), Standard Deviations (sd), and Numbers of Subjects (n) for OL and SL Tasks

Subjects OL Data	Relevant Dimension in OL OL Data	Shift	OL Data M	OL Data sd	OL Data n	SL Data M	SL Data sd	SL Data n*
NORMALS M = 7.2 sd = 10.6 n = 80	CENTRAL FIGURES M = 3.3 sd = 6.6 n = 40	CS	3.0	4.0	8	2.5	1.2	8
		ID	1.7	1.6	16	0.4	0.5	16
		ED	5.1	9.8	16	16.6	12.4	14
	DOTS M = 11.0 sd = 11.2 n = 40	CS	9.3	9.4	8	1.9	1.4	7
		ID	13.2	11.3	16	0.8	0.6	12
		ED	9.8	12.3	16	11.4	11.6	12
RETARDATES M = 17.4 sd = 13.0 n = 80	CENTRAL FIGURES M = 8.8 sd = 11.4 n = 40	CS	14.0	14.3	8	23.0	14.0	4
		ID	6.1	8.2	16	0.3	0.5	15
		ED	8.9	11.3	16	24.4	10.7	13
	DOTS M = 26.0 sd = 8.2 n = 40	CS	26.3	7.0	8	15.0	21.2	2
		ID	23.6	10.8	16	0.4	0.5	5
		ED	28.2	5.1	16	10.0	1.4	2

* n may be smaller in SL due to some subjects' failing to reach criterion by trial 30 in OL

Table 5

Mean Trials of Last Error (M), Standard Deviations (sd), Numbers of Subjects (n), and Analysis of Variance for N and R Performance in OL

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	3.3	6.6	40	11.0	11.2	40
Retardates	8.8	11.4	40	26.0	8.2	40

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	4,473.2	1	4,473.2	48.7	0.000
B (Condition)	5,808.1	1	5,808.1	63.2	0.000
A x B	765.6	1	765.6	8.3	0.004
Error	14,340.7	156	91.9		
	Scheffé tests:		N vs. R on CF	3.1	$>.05$
			N vs. R on Dots	48.6	$<.001$

OL, Ns learned significantly more quickly than Rs. Judging by the mean trial of last error (26.0), the Dots condition was very difficult for Rs to solve, with many subjects failing to reach criterion. It appears that dimension difficulty is an important variable in comparing the discrimination learning performance of Ns and Rs. Only when the difficult dimension (Dots) is relevant to solution, does the hypothesized learning superiority of Ns clearly emerge.

Hypothesis 1.2, that based on the total subjects, the percentage of learners in OL will be higher for Ns than for Rs was again only partially supported. While there was a significantly greater percentage of N than R learners in the Dots condition (Ns = 78%, Rs = 23%; χ^2 = 18.1, df = 1, p-one tail $<$ .001), there was no significant difference between the percentage of N and R learners in the CF condition (Ns = 95%, Rs = 80%: χ^2 = 0.7, df = 1, p-one tail = .50). These results concur with the dimensional difficulty effect found in the previous analysis.

Because of the presence of the dimensional difficulty effect in OL, it could not be assumed that the probability of attending to the relevant dimension was equally high for the CF and Dots dimensions during discrimination learning. Since hypotheses involving comparisons across shifts or samples require the assumption of equality of dimensional attending responses, it was not possible to collapse the data over the two dimensions. Consequently, where dimensional difficulty could possibly affect performance in SL, separate analyses were employed for the CF and Dots dimensions.

Since for each of these dimensions, there were sixteen subjects

in the various ID and ED shift conditions and eight subjects in the CS conditions, analyses involving OL data were not hampered by minimal numbers of subjects (See Table 4). However, the fifty subjects who failed to reach the criterion of nine consecutive correct responses in OL were dropped from the SL sample; thus the number of subjects in some cells on SL was drastically reduced.

In particular, three cells contained very few Rs: ED shift from Dots to CF (two subjects), CS involving Dots (two subjects) and CS involving CF (four subjects). It is acknowledged that the data from such small numbers of subjects may be biased, and the tentative nature of the results involving these cells is stressed; nevertheless, they are included in order that some indication be given of the comparative performance of subjects under easy and difficult discrimination task conditions, and some basis be provided for eye movement comparisons on ID and ED shifts, as outlined in the next chapter.

II. Comparison of Performance in ID Shift, ED Shift and CS

Hypothesis 2.1, that for OL learners the mean trial of last error in SL will be ordered such that ID shift < CS < ED shift, was supported. The mean trials of last error, standard deviations, numbers of subjects and analyses used are listed in Table 6. Because of the dimensional difficulty effect found in the previous analyses, separate analyses were run here for the CF and Dots conditions. Nevertheless, it is seen that for both dimensions ID shift is learned in fewer trials than CS, thereby suggesting a positive transfer effect for ID shift, while CS is

Table 6

Mean Trials of Last Error (M), Standard Deviations (sd), Numbers of Subjects (n), and Analyses for ID Shift, ED Shift and CS Comparisons

Condition	Task	M	sd	n	t	Df	P
CF	ID	0.4	0.5	31			
	CS	9.3	12.5	12	2.466*	11.013**	0.018
Dots	ID	0.7	0.6	17			
	CS	4.6	5.6	9	2.609*	8.008**	0.015
CF	CS	9.3	12.5	12			
	ED	20.4	12.0	27	2.70	37	0.006
Dots	CS	4.6	5.6	9			
	ED	11.2	10.6	14	1.67	21	0.054

* t' test ** Adjusted df

learned in fewer trials than ED shift, thereby indicating a negative transfer effect for ED shift.

Hypothesis 2.2, that for OL learners the percentage of learners in SL will be ordered such that ID shift > CS > ED shift, was supported in the CF condition but not in the Dots condition. In the CF condition, the percentage of learners for ID shift, CS and ED shift was 100%, 75% and 41%, respectively, producing a significant difference between ID shift and CS ($\chi^2 = 4.9$, df = 1, p-one tail $< .02$) as well as between CS and ED shift ($\chi^2 = 2.7$, df = 1, p-one tail = .05).

In the Dots condition, the percentage of learners was 100%, 89% and 79% for ID shift, CS and ED shift, respectively. Although in the predicted direction, no significant difference was found between ID shift and CS ($\chi^2 = 0.1$, df = 1, p-one tail = .68) nor between CS and ED shift ($\chi^2 = 0.005$, df = 1, p = .96) in the Dots condition.

III. Comparison of N and R Performance in ID Shift, ED Shift and CS

ID Shift

Hypothesis 3.1, that for OL learners there will be no difference between Ns and Rs in the mean trial of last error in ID shift, was supported for both dimensions (See Table 7).

Hypothesis 3.2, that for OL learners there will be no difference in percentage of N and R learners in ID shift, was supported as well for both the CF ($\chi^2 = 0.47$, df = 1, p-two tail = .50) and Dots ($\chi^2 = 0.02$, df = 1, p-two tail = .88) conditions. In the CF condition, 100% of the Ns and 94% of the Rs learned the ID shift task, while in the Dots

Table 7

Mean Trials of Last Error (M), Standard Deviations (sd), Numbers of Subjects (n), and Analysis of Variance for N and R Performance in ID Shift

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	0.4	0.5	16	0.8	0.6	12
Retardates	0.3	0.5	15	0.4	0.5	5

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	0.7	1	0.7	2.3	0.133
B (Condition)	0.5	1	0.5	1.7	0.196
A x B	0.1	1	0.1	0.3	0.601
Error	12.3	44	0.3		

condition, 100% of both the Ns and the Rs learned the task.

It should be pointed out that because there was no difference between Ns and Rs in learning the OL discrimination when CF were relevant, the equal performance of Ns and Rs in the CF condition of ID shift cannot provide a test of attention theory on ID shift.

ED Shift

Hypothesis 3.3, that for OL learners Ns will have a lower mean trial of last error than Rs on ED shift, was not supported for either the CF or Dots conditions (See Table 8). It would thus appear that evidence has not been found for the Zeaman and House assumption that Ns are more likely to attend to the more critical dimensions when faced with a new task than Rs. Nevertheless, from Table 8 it may be seen that the difference in mean scores between Ns (16.6) and Rs (24.4) in the CF condition is in the predicted direction. In other words, when the shift was to a difficult dimension (Dots), there was a greater tendency for Ns to attend to the relevant dimension than Rs. This tendency reflects the difficulty effect observed in OL with Dots.

Hypothesis 3.4, that for OL learners a higher percentage of Ns than Rs will learn ED shift, was not supported in the CF condition (χ^2 = 1.98, df = 1, p-one tail = .08) nor in the Dots condition (χ^2 = 0.02, df = 1, p-one tail = .45). In the CF condition, 57% of the Ns and 23% of the Rs learned the ED shift task, while in the Dots condition, 75% of the Ns and 100% of the Rs learned the ED shift task. While it seems surprising that 100% of the Rs learned the Dots condition task in ED shift, this result may be partially attributable to the elimination

Table 8

Mean Trials of Last Error (M), Standard Deviations (sd), Numbers of Subjects (n), and Analysis of Variance for N and R Performance in ED Shift

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	16.6	12.4	14	11.4	11.6	12
Retardates	24.4	10.7	13	10.0	1.4	2

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	54.7	1	54.7	0.4	0.521
B (Condition)	525.6	1	525.6	4.0	0.052
A x B	114.6	1	114.6	0.9	0.355
Error	4,829.2	37	130.5		

of R subjects through failure to learn the OL task, thereby leaving only two subjects in ED shift in this condition.

Control Shift

Hypothesis 3.5, that for OL learners Ns will have a lower mean trial of last error than Rs on CS, was supported for the CF condition, but not for the Dots condition (See Table 9). Inspection of the last error scores in Table 9, however, indicates that Rs took considerably more trials to learn than Ns in both the CF and Dots conditions. It is suggested that the small number of Rs involved in the Dots analyses may have been insufficient to yield significant results in spite of the large discrepancy in N and R scores.

Hypothesis 3.6, that for OL learners a higher percentage of Ns than Rs will learn in CS was again supported for the CF condition (χ^2 = 4.5, df = 1, p-one tail = .02) but not for the Dots condition (χ^2 = 0.5, df = 1, p-one tail = .26). In the CF condition 100% of the Ns and 25% of the Rs learned the CS task, while in the Dots condition 100% of the Ns and 50% of the Rs learned the task.

Summary and Discussion of Performance Results

The results of analyses relating to performance data hypotheses are summarized in Table 10. Some of the parametric analyses involving R performance in CS and ED shift with Dots were run with less than five subjects. These results were considered tentative and are indicated in Table 10 by an asterisk. Alpha level was set at .05 for all analyses. Mean trial of last error and percentage of learners constituted the

Table 9

Mean Trials of Last Error (M), Standard Deviations (sd), Numbers of Subjects (n), and Analyses for N and R Performance in CS

Condition	Intelligence	M	sd	n	*t*'	Adj. df	P
CF	N	2.5	1.2	8	2.9	3.0	0.030
	R	23.0	14.0	4			
Dots	N	1.9	1.4	7	0.9	1.0	0.271
	R	15.0	21.2	2			

Table 10

Summary of Results for Performance Data

Hypothesis		Dependent Variable	Task	Condition	
				CF	Dots
I.	1.1	Trial of last error	OL	N = R	N < R
	1.2	Percentage of learners	OL	N = R	N > R
II.	2.1	Trial of last error		ID < CS < ED	ID < CS < ED
	2.2	Percentage of learners		ID > CS > ED	ID = CS = ED
III.	3.1	Trial of last error	ID	N = R	N = R
	3.2	Percentage of learners	ID	N = R	N = R
	3.3	Trial of last error	ED	N = R	N = R*
	3.4	Percentage of learners	ED	N = R	N = R
	3.5	Trial of last error	CS	N < R*	N = R*
	3.6	Percentage of learners	CS	N > R	N = R

* less than five subjects in a cell

dependent variables.

In the table, "condition" indicates the dimension which was relevant to solving the discrimination problem, and is based on the relevant dimension in OL, regardless of the comparisons which are involved. Separate analyses were run for the CF and Dots dimensions in order to more fully investigate shift effects, since when CF constituted the relevant dimension, the learning task was found to be considerably easier than when Dots constituted the relevant dimension.

I. Comparison of N and R Performance in OL

In Zeaman and House attention theory, retarded children are considered to have a low initial probability of attending to the relevant dimension. This assumption was only partly borne out by the results of Hypotheses 1.1 and 1.2, for on the easy dimension no difference was found between Ns and Rs in learning the original task. It was only on the difficult dimension that Ns learned the discrimination more quickly than Rs. Thus, it appears that the attention deficit attributed to retarded children may be qualified in terms of task difficulty.

II. Comparison of Performance in ID Shift, ED Shift and CS

Zeaman and House have also postulated that the probability of attending to the relevant dimension once learning has occurred is high, and that this attending response is capable of transfer. It is suggested that transfer to an ID shift, which arranges for positive transfer, is the easiest to learn while transfer to an ED shift, which arranges for negative transfer, is the most difficult. Transfer to a CS is

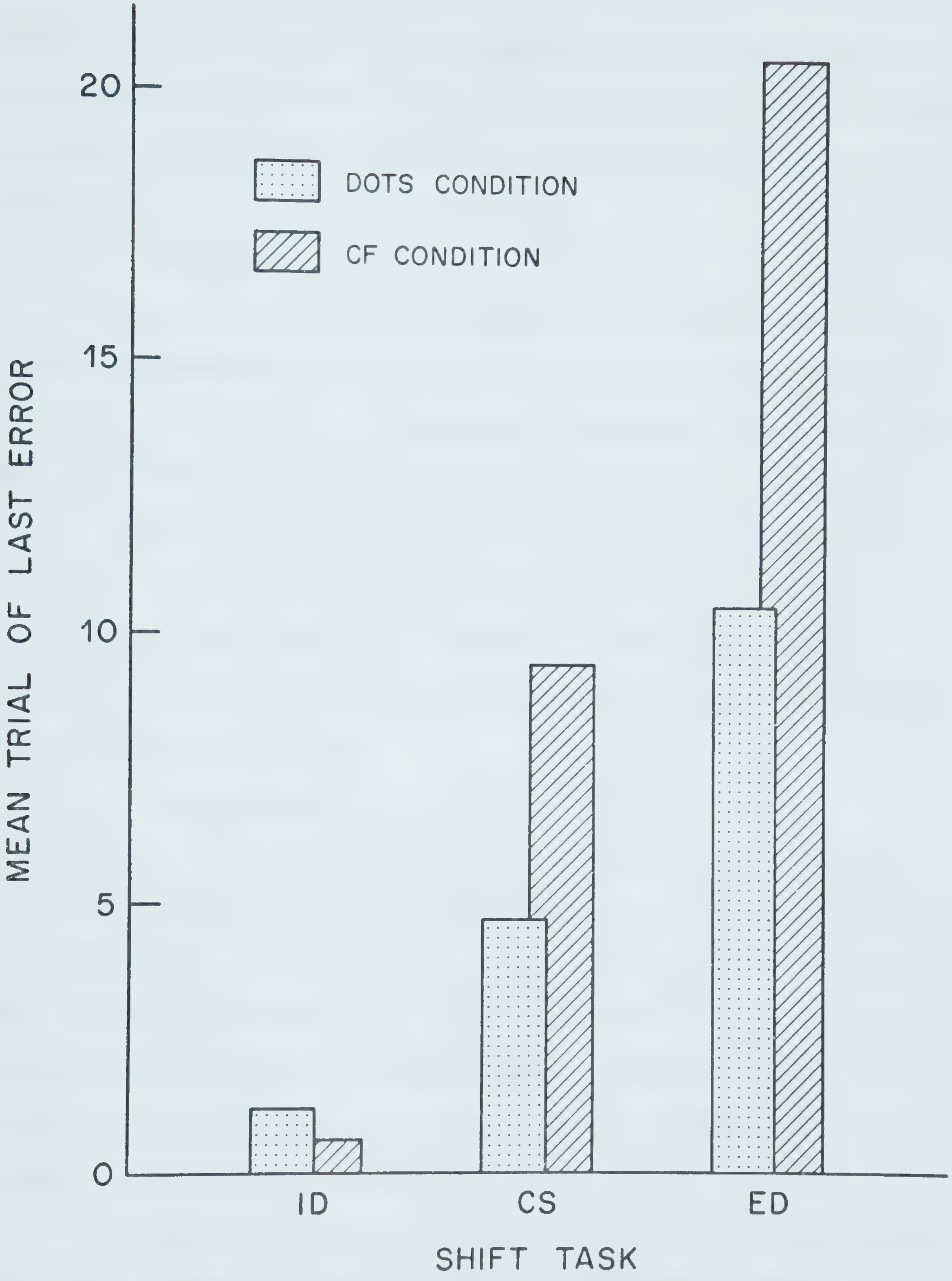
considered to be of intermediate difficulty. The results of Hypothesis 2.1 indicate this to have been the case, with ID shift being learned more quickly than both CS and ED shift, and CS being learned more quickly than ED shift, regardless of task condition (See Figure 3). This would indicate the presence of positive and negative transfer effects in the ID and ED shift tasks, respectively, as predicted by attention theory.

The results for Hypothesis 2.2 revealed the predicted order of difficulty for the CF condition but not for the Dots condition. The reason for the percentage of learners for the Dots condition being uniformly high in the shift tasks may lie in a dimension difficulty effect, with the slowest subjects having been eliminated in OL.

III. Comparison of N and R Performance in ID Shift, ED Shift and CS

ID Shift

Because transfer to ID shift maintains the same relevant dimension as OL, the probability of attending to the relevant dimension is considered to be as high for Rs as for Ns at the commencement of ID shift. In keeping with the expectation that Ns and Rs should not differ in performance on ID shift, no difference between Ns and Rs was found for either Hypothesis 3.1 or 3.2. Although these results apply to both the CF and Dots conditions, only the results for the latter are a test of attention theory. When Dots were relevant, Rs learned the OL task more slowly than Ns; for them to perform as well as Ns on the subsequent ID shift is supportive of attention theory. Since ID shift provides for



Performance in ID Shift, ED Shift and CS

Figure 3

dimensional transfer only, the improved discrimination performance of Rs, relative to Ns, in the Dots condition must be attributed to their having learned to attend to the relevant dimension in OL, as Zeaman and House contend.

ED Shift

Because transfer to ED shift makes the irrelevant dimension in OL relevant in ED shift, speed of learning this shift task depends on increasing the probability of observing the previously irrelevant dimension. Although Ns were hypothesized to attend to this dimension more rapidly than Rs, the results of Hypotheses 3.3 and 3.4 indicated no difference between Ns and Rs in speed of learning the ED shift task. Thus no support was found for the Zeaman and House assumption that Ns are able to select the important dimensions in discrimination tasks with greater efficiency than Rs.

Control Shift

Because totally new dimensions are introduced in transfer to a CS, it was assumed that Ns would learn the CS task more quickly than Rs, on analogy with OL. This expectation was found only for the CF condition for both Hypotheses 3.5 and 3.6. The analyses for the Dots condition may have been hampered by small numbers of subjects, particularly in terms of mean trial of last error where a large discrepancy was in fact evident between Ns and Rs in CS.

It is interesting that although CS is in a sense a second attempt at OL, the results for CS and OL differ in dimensional effects. In OL no difference was found between Ns and Rs in the CF condition, while in

CS no difference was found in the Dots condition. Two reasons are suggested for this difference. The CS may embody a "learning to learn" or practice effect (Reese and Lipsitt, 1970, p.270-278) which interacts with dimension difficulty. Also CS subjects were not filmed as they solved the discrimination shift task, while the majority of the OL subjects (128/160) were filmed. Again the filming process may have interacted with dimension difficulty.

In brief, from the performance data, there appears to be evidence in support of Zeaman and House attention theory. An initial deficit appears to characterize discrimination learning in educable mentally retarded children -- but only when the discrimination task is difficult. When the task is easy, Rs appear to attend as well as their CA matched Ns, in spite of the vast difference in IQ. There also appears to be evidence in support of positive and negative transfer, since speed of learning the shift tasks was such that ID shift $<$ CS $<$ ED shift, in terms of difficulty. Additional support for the theory of Zeaman and House appears in the elimination of the retardate attention deficit on the difficult discrimination in ID shift, as may be seen from the similar performance of Ns and Rs.

CHAPTER 6

EYE MOVEMENT DATA

Comparisons for each of the eye movement variables paralleled as closely as possible the comparisons which had been drawn for the discrimination performance data. The exceptions concerned CS, as there were no recorded eye movements for subjects in this condition.

With the performance data, it had been found necessary to test hypotheses separately for the CF and Dots dimensions, due to variable task difficulty. Since comparisons were intended between the dimensional identification (performance) and observing response (eye movements) aspects of attention theory, and furthermore, since task difficulty could conceivably relate to looking behavior, data were analyzed separately by dimension for each eye movement variable, as was the case for the performance data. Classification by dimension was based on relevant dimension in OL, as before.

The number of subjects involved in each eye movement analysis was identical to the comparable performance analysis. As indicated in Table 4, there were sixteen subjects in each of the eight filmed OL cells, but because those children who failed to learn the OL task were dropped from shift analysis, there were varying numbers of subjects in each of the SL cells.

The eye movement variables included frames on relevant dimension, frames on irrelevant dimension, total shifts, left-right shifts, and unscorable frames. Each variable was derived for each subject by summing for the first thirty frames (three seconds) in each trial

over the eight filmed trials in each of OL and SL.

Because attending to the previously relevant dimension is not reinforced, and consequently is open to extinction in the first few trials of ED shift, it appeared that differences in looking behavior related to attending response might be obliterated by summing for eight trials. Accordingly, the analyses involving ED shift were carried out for each of the first four trials and summed over eight trials on all of the eye movement variables. The results of these analyses were similar. Consequently, results for the summed eight trials are reported also for ED shift.

A two (N and R) x two (CF and Dots) analysis of variance was employed for all hypotheses, with alpha set at .05. If heterogeneity of variance was found, Welch's *t*' tests were employed (See Winer, p.37).

Results for Eye Movement Hypotheses

I. Comparison of Eye Movement Patterns of Ns and Rs in OL

Hypothesis 4.1, that for the total filmed samples Ns will look at the relevant dimension on more frames than Rs in OL, was not supported for either the CF or Dots conditions (See Table 11). Contrary to expectation, Ns and Rs did not differ in time spent observing the relevant dimension in the OL task. However, all subjects looked significantly more at the CF stimuli than the Dots.

Hypothesis 4.2, that for the total filmed samples Ns will look at the irrelevant dimension on fewer frames than Rs in OL, was not supported either for the two conditions (See Table 12). Again contrary

Table 11

Mean Frames on Relevant Dimension (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for N and R Eye Movement Patterns in OL

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	140.4	27.7	32	68.0	30.9	32
Retardates	148.9	33.5	32	61.5	23.3	32

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	32.0	1	32.0	0.0	0.846
B (Condition)	204,480.0	1	204,480.0	242.0	0.000
A x B	1,800.0	1	1,800.0	2.1	0.147
Error	104,756.0	124	844.8		

Table 12

Mean Frames on Irrelevant Dimension (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for N and R Eye Movement Patterns in OL

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	70.4	25.7	32	135.5	32.6	32
Retardates	59.2	31.9	32	146.9	34.4	32

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	0.2	1	0.2	0.0	0.989
B (Condition)	186,890.0	1	186,890.0	190.4	0.000
A x B	4,106.0	1	4,106.0	4.2	0.053
Error	121,743.0	124	981.8		

to expectation, no difference was found between Ns and Rs in looking at the irrelevant dimension. Nevertheless, CF were looked at significantly more than the Dots, even though irrelevant to solution of the discrimination task.

Hypothesis 4.3, that for the total filmed samples Ns will have fewer unscorable frames than Rs in OL, was supported for both the CF and Dots conditions (See Table 13). Thus Ns were seen to be less distractible generally than Rs. Furthermore, unscorable frames were constant over the two stimulus conditions.

II. Comparison of Eye Movement Patterns in ID and ED Shifts

Hypothesis 5.1, that for filmed OL learners there will be a greater number of frames on relevant dimension in ID shift than ED shift, was supported for the CF condition, but no difference was found in the Dots condition (See Table 14).

Hypothesis 5.2, that for filmed OL learners there will be a smaller number of frames on irrelevant dimension in ID shift than in ED shift, was similarly supported for the CF condition but not for the Dots condition (See Table 14).

While the results of Hypotheses 5.1 and 5.2 appear to support attention theory in the CF condition, it should be pointed out by way of qualification that in this condition, ID shift had CF relevant while ED shift had Dots relevant. Thus the differences obtained may have been due to a dimensional difficulty effect.

Table 13

Mean Unscorable Frames (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for N and R Eye Movement Patterns in OL

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	9.3	12.0	32	9.9	15.7	32
Retardates	14.1	12.2	32	15.9	19.0	32

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	935.5	1	935.5	4.1	0.044
B (Condition)	47.5	1	47.5	0.2	0.647
A x B	11.3	1	11.3	0.1	0.823
Error	27,972.9	124	225.6		

Table 14

Mean Frames (M) on Relevant and Irrelevant Dimensions, Standard Deviations (sd), Numbers of Subjects (n) and Analyses for Eye Movements in ID and ED Shifts

Eye Movement Variable	Condition	Shift	M	sd	n	t'	Adj. df	P
Frames on Relevant Dimension	CF	ID	143.7	43.2	31			
		ED	54.1	27.7	27	6.5	52.3	0.000
	Dots	ID	93.5	45.5	17			
		ED	108.5	98.9	14	0.5	21.6	0.502
Frames on Irrelevant Dimension	CF	ID	52.4	38.3	31			
		ED	150.7	47.6	27	7.3	54.5	0.000
	Dots	ID	90.4	48.8	17			
		ED	107.8	103.6	14	0.3	20.4	0.398

III. Comparison of Eye Movement Patterns of Ns and Rs in ID Shift and ED Shift

ID Shift

Hypothesis 6.1, that for filmed OL learners there will be no difference between Ns and Rs in number of frames on relevant dimension in ID shift, was not supported for either the CF or the Dots condition (See Table 15). Surprisingly, Rs were found to look more at the relevant dimension in ID shift than Ns.

Hypothesis 6.2, that for filmed OL learners there will be no difference between Ns and Rs in the number of frames on irrelevant dimension in ID shift, was supported for both conditions (See Table 16). While this finding is in agreement with the prediction from attention theory, the fact that no difference was found in OL on the irrelevant dimension minimizes its significance here.

Hypothesis 6.3, that for filmed OL learners there will be fewer unscorable frames for Ns than for Rs in ID shift, was supported for both conditions (See Table 17). Ns were thus seen to be able to concentrate more on the stimuli during ID shift than Rs.

ED Shift

Hypothesis 6.4, that for filmed OL learners Ns will have more frames on relevant dimension than Rs in ED shift, was not supported for either the CF or the Dots condition (See Table 18). Contrary to expectation, Ns and Rs did not differ in observing the relevant dimension in ED shift.

Hypothesis 6.5, that for filmed OL learners Ns will have fewer frames on irrelevant dimension than Rs in ED shift, was not supported

Table 15

Mean Frames on Relevant Dimension (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for Eye Movement Patterns in ID Shift

Intelligence	Condition CF			Condition Dots		
	M	sd	n	M	sd	n
Normals	134.1	37.6	16	70.2	47.8	12
Retardates	153.3	45.5	15	116.8	30.4	5

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	10,510.0	1	10,510.0	5.8	0.020
B (Condition)	24,482.2	1	24,482.2	13.6	0.001
A x B	1,832.5	1	1,832.5	1.0	0.319
Error	79,079.6	44	1,797.3		

Table 16

Mean Frames on Irrelevant Dimension (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for Eye Movement Patterns in ID Shift

Intelligence	Condition CF M	CF sd	CF n	Condition Dots M	Dots sd	Dots n
Normals	59.6	31.6	16	93.1	51.9	12
Retardates	45.3	41.1	15	87.8	15.5	5

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	929.3	1	929.3	0.6	0.447
B (Condition)	14,022.4	1	14,022.4	8.9	0.005
A x B	196.9	1	196.9	0.1	0.725
Error	69,294.6	44	1,574.9		

Table 17

Mean Unscorable Frames (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for Eye Movement Patterns in ID Shift

Intelligence	CF			Dots		
	M	sd	n	M	sd	n
Normals	10.1	13.3	16	6.8	16.3	12
Retardates	23.9	43.2	15	25.2	30.5	5

Condition spans CF and Dots.

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	3,319.7	1	3,319.7	4.3	0.044
B (Condition)	10.1	1	10.1	0.1	0.909
A x B	53.8	1	53.8	0.1	0.792
Error	33,742.5	44	766.9		

Table 18

Mean Frames on Relevant Dimension (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for Eye Movement Patterns in ED Shift

Intelligence	Condition CF M	sd	n	Dots M	sd	n
Normals	60.5	28.0	14	121.1	29.1	12
Retardates	47.6	25.5	13	96.0	53.5	2

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	1,970.1	1	1,970.1	1.9	0.177
B (Condition)	16,228.2	1	16,228.2	15.6	0.000
A x B	203.3	1	203.3	0.2	0.661
Error	38,517.6	37	1,041.0		

as well for both stimulus conditions (See Table 19). Ns and Rs did not differ in observing the irrelevant dimension in ED shift.

Hypothesis 6.6, that for filmed OL learners there will be fewer unscorable frames for Ns than for Rs in ED shift, was supported for both the CF and Dots conditions (See Table 20). Once again Ns were seen to be less distractible generally than Rs.

IV. Comparison of Eye-shift Activity

Hypothesis 7.1, that for the total filmed samples there will be no difference between Ns and Rs on total shifts and left-right shifts in OL, was supported only for total shifts (See Table 21). Thus the total eye-shift activity of Ns and Rs did not differ in OL, but Rs exhibited more left-right eye-shifts than Ns in OL. These results were found for both the CF and Dots conditions.

Hypothesis 7.2, that for filmed OL learners there will be no difference between ID and ED shifts on total eye-shifts and left-right eye-shifts, was supported for both the CF and Dots conditions (See Table 22). Thus in terms of eye-shift activity, no difference was found between ID and ED shifts.

Hypothesis 7.3, that for filmed OL learners there will be no difference between Ns and Rs on total shifts and left-right shifts in ID shift, was partially supported (See Table 23). Contrary to expectation, Ns had fewer total shifts than Rs in the Dots condition, and fewer left-right shifts than Rs in both the CF and Dots conditions. However, no difference in total eye-shift activity was found between Ns

Table 19

Mean Frames on Irrelevant Dimension (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for Eye Movement Patterns in ED Shift

Intelligence	Condition CF			Condition Dots		
	M	sd	n	M	sd	n
Normals	144.8	26.6	14	87.7	30.7	12
Retardates	156.7	48.2	13	128.0	66.2	2

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	3,729.8	1	3,729.8	2.3	0.139
B (Condition)	10,064.9	1	10,064.9	6.1	0.018
A x B	1,104.3	1	1,104.3	0.7	0.417
Error	60,597.9	37	1,637.8		

Table 20

Mean Unscorable Frames (M), Standard Deviations (sd), Numbers of Subjects (n) and Analysis of Variance for Eye Movement Patterns in ED Shift

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	6.1	8.1	14	5.1	7.3	12
Retardates	18.1	17.5	13	15.0	6.9	2

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	634.3	1	634.3	4.6	0.039
B (Condition)	425.1	1	425.1	3.1	0.087
A x B	329.1	1	329.1	2.4	0.131
Error	5,102.1	37	137.9		

Table 21

Mean Scores (M), Standard Deviations (sd), Numbers of Subjects (n), and Analyses of Variance for Total Shifts and Left-right Shifts in OL

TOTAL SHIFTS

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	39.3	10.1	32	36.4	11.6	32
Retardates	39.1	9.5	32	39.3	12.3	32

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	52.6	1	52.6	0.4	0.509
B (Condition)	60.5	1	60.5	0.5	0.479
A x B	71.9	1	71.9	0.6	0.440
Error	14,888.7	124	120.1		

LEFT-RIGHT SHIFTS

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	18.0	5.1	32	17.0	6.8	32
Retardates	19.0	4.7	32	20.8	7.5	32

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	185.3	1	185.3	4.9	0.028
B (Condition)	4.5	1	4.5	0.1	0.729
A x B	63.3	1	63.3	1.7	0.196
Error	4,642.8	124	37.4		

Table 22

Mean Scores (M), Standard Deviations (sd), Numbers of Subjects and Analyses for Total Shifts and Left-right Shifts in ID and ED Shifts

Eye Movement Variable	Condition	Shift	M	sd	n	t'	Adj. df	P
Total Shifts	CF	ID	31.5	13.6	31	1.0	41.4	0.337
		ED	35.3	10.7	27			
	Dots	ID	31.5	12.1	17	0.9	27.8	0.397
		ED	32.0	7.9	14			
Left-right Shifts	CF	ID	14.6	6.1	31	1.9	42.1	0.064
		ED	17.1	7.2	27			
	Dots	ID	13.0	8.4	17	1.4	26.3	0.168
		ED	14.7	5.1	14			

Table 23

Mean Scores (M), Standard Deviations (sd), Numbers of Subjects (n), and Analyses of Variance for Total Shifts and Left-right Shifts in ID Shift

TOTAL SHIFTS

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	33.4	14.8	16	23.2	12.4	12
Retardates	29.5	9.1	15	39.8	8.9	5

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	387.7	1	387.7	2.7	0.111
B (Condition)	0.1	1	0.1	0.0	0.986
A x B	1,014.2	1	1,014.2	6.9	0.012
Error	6,436.7	44	146.3		
	Scheffé tests:		N vs. R on CF	0.6	> .05
			N vs. R on Dots	6.6	< .05

LEFT-RIGHT SHIFTS

Intelligence	Condition					
	CF			Dots		
	M	sd	n	M	sd	n
Normals	14.4	6.0	16	9.4	5.2	12
Retardates	14.8	5.0	15	16.6	7.3	5

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	138.0	1	138.0	4.3	0.044
B (Condition)	25.2	1	25.2	0.8	0.382
A x B	112.8	1	112.8	3.5	0.068
Error	1,416.5	44	32.2		

and Rs in the CF condition only.

Hypothesis 7.4, that for filmed OL learners there will be no difference between Ns and Rs on total shifts and left-right shifts in ED shift, was supported in both the CF and Dots conditions (See Table 24). Thus Ns and Rs appeared to have similar eye-shift activity in ED shift.

Summary and Discussion of Eye Movement Results

A summary of findings relating to eye movement data is presented in Table 25. Statistical treatment of these data was similar to that of the performance data. Alpha level was set at .05 for all analyses. Separate analyses were run for the CF and Dots dimensions. Those analyses which were run with less than five subjects in a cell yielded tentative findings and are indicated in the table by an asterisk.

I. Comparison of Eye Movement Patterns of Ns and Rs in OL

In accordance with the theories of Zeaman and House (1963), it was expected that Rs would exhibit a deficit in initial observing response, as measured by various eye movement variables. In line with the assumption that Rs have a lesser tendency to attend to the relevant dimension than Ns in a discrimination learning task, it was hypothesized that Ns would fixate more on the relevant dimension and less on the irrelevant dimension than Rs in OL. Contrary to expectation, neither of these hypotheses was supported. Ns and Rs did not differ in the number of frames spent looking at either the relevant dimension (Hypothesis 4.1) or the irrelevant dimension (Hypothesis 4.2). In other words, no

Table 24

Mean Scores (M), Standard Deviations (sd), Numbers of Subjects (n), and Analyses of Variance for Total Shifts and Left-right Shifts in ED Shift

TOTAL SHIFTS

Intelligence	CF M	CF sd	CF n	Dots M	Dots sd	Dots n
Normals	35.7	12.4	14	39.5	13.4	12
Retardates	34.8	9.3	13	24.5	7.8	2

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	344.2	1	344.2	2.5	0.123
B (Condition)	58.9	1	58.9	0.4	0.518
A x B	272.9	1	272.9	1.9	0.168
Error	5,100.1	37	137.9		

LEFT-RIGHT SHIFTS

Intelligence	CF M	CF sd	CF n	Dots M	Dots sd	Dots n
Normals	15.1	5.6	14	15.9	5.0	12
Retardates	19.1	7.1	13	13.5	0.7	2

Source	Sums of Squares	Df	Mean Squares	F Ratio	P
A (Intelligence)	3.5	1	3.5	0.1	0.756
B (Condition)	30.6	1	30.6	0.8	0.357
A x B	56.4	1	56.4	1.6	0.213
Error	1,301.3	37	35.2		

Table 25

Summary of Results for Eye Movement Data

Hypothesis		Dependent Variable	Task	Condition CF	Condition Dots
I.	4.1	Relevant Dimension	OL	N = R	N = R
	4.2	Irrelevant Dimension	OL	N = R	N = R
	4.3	Unscorable Frames	OL	N < R	N < R
II.	5.1	Relevant Dimension		ID > ED	ID = ED
	5.2	Irrelevant Dimension		ID < ED	ID = ED
III.	6.1	Relevant Dimension	ID	N < R	N < R
	6.2	Irrelevant Dimension	ID	N = R	N = R
	6.3	Unscorable Frames	ID	N < R	N < R
	6.4	Relevant Dimension	ED	N = R	N = R*
	6.5	Irrelevant Dimension	ED	N = R	N = R*
	6.6	Unscorable Frames	ED	N < R	N < R*
IV.	7.1	Total Shifts	OL	N = R	N = R
		Left-right Shifts	OL	N < R	N < R
	7.2	Total Shifts		ID = ED	ID = ED
		Left-right Shifts		ID = ED	ID = ED
	7.3	Total Shifts	ID	N = R	N < R
		Left-right Shifts	ID	N < R	N < R
	7.4	Total Shifts	ED	N = R	N = R*
		Left-right Shifts	ED	N = R	N = R*

* less than 5 subjects in a cell

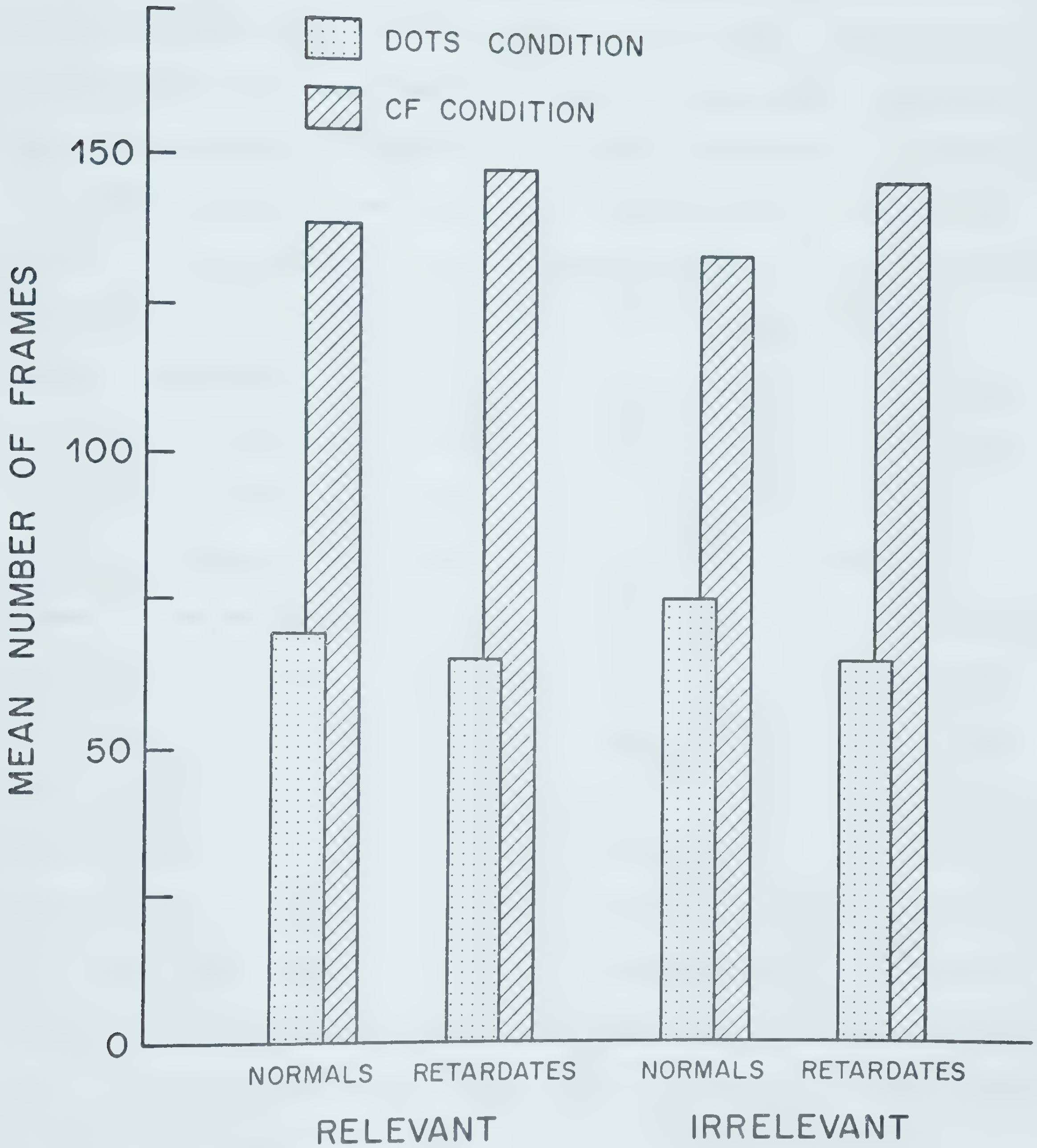
evidence of an attention deficit in terms of differential looking behavior for Rs was found in the OL task (See Figure 4). Nevertheless, as may be seen from the figure, Ns and Rs both spent more frames looking at the CF stimuli than the Dots, regardless of whether they were relevant to solution or not.

That there should be no difference in dimensional looking behavior of Ns and Rs is also at variance with the findings of Muir (1971). The reasons for this discrepancy in results may arise from differences in analytic technique. In Muir's study, data for criterial trials were eliminated from eye movement analyses, in contrast to the present study where such data were retained. It is possible that since Ns tended to learn the discrimination task more quickly than the Rs, their eye movement data may have been drawn from trials where they no longer needed to search for a solution. Nevertheless, preliminary analyses of the first two trials in OL, when no subject could be certain of having the solution, revealed no difference in looking at the relevant and irrelevant dimensions either.

For unscorable frames, it was hypothesized that Rs, being more generally distractible than Ns, would exhibit more unscorable frames in OL, and this was supported (Hypothesis 4.3). Thus Rs appeared to be more susceptible to general inattention in OL than Ns, as Muir (1971) has reported.

II. Comparison of Eye Movement Patterns in ID and ED Shifts

It was assumed in this study that eye movements are capable of



Observing Response of Normals and Retardates to the CF and Dots Stimuli

When Relevant and Irrelevant to Task Solution in OL

Figure 4

the dimensional transfer postulated by Zeaman and House. In particular, the eye movement variables of frames on relevant and irrelevant dimensions were considered to reflect positive dimensional transfer to an ID shift and negative dimensional transfer to an ED shift. It was expected that there should be more frames on the relevant dimension, and fewer frames on the irrelevant dimension, in ID shift as compared to ED shift.

When the comparisons were carried out, however, an interaction was noted between dimensional salience and discrimination shift task on both frames on relevant dimension (Hypothesis 5.1) and irrelevant dimension (Hypothesis 5.2) In the CF condition (where CF were relevant in ID shift and Dots were relevant in ED shift), there were more frames on the relevant dimension and fewer frames on the irrelevant dimension in ID shift as hypothesized. But in the Dots condition, where the relevant dimension for the two shift conditions was reversed, there were equal frames on relevant and irrelevant dimensions in ID and ED shifts. Thus it would seem that when an ID shift (positive transfer) involving the more salient dimension (CF) was compared with an ED shift (negative transfer) involving the more difficult dimension (Dots), the hypothesized difference between eye movements in ID and ED shifts was observed. On the other hand, when an ID shift involving the more difficult dimension (Dots) was compared with an ED shift involving the easier dimension (CF), no difference was found between ID and ED shifts. It would appear, then, that the dimension with greater salience augmented positive transfer and diminished negative transfer, while the opposite held for the dimension with lesser salience.

In Figure 5, the eye movements of a normal and an educable mentally retarded subject are sketched on different trials. It is apparent that both subjects spent more time looking at the CF stimuli than at the Dots. The interaction between dimensional salience and negative transfer is evident in the ED shift trial, for even though the subject was transferred from a Dots condition, there is greater looking at the CF stimuli.

III. Comparison of Eye Movement Patterns of Ns and Rs in ID and ED Shifts

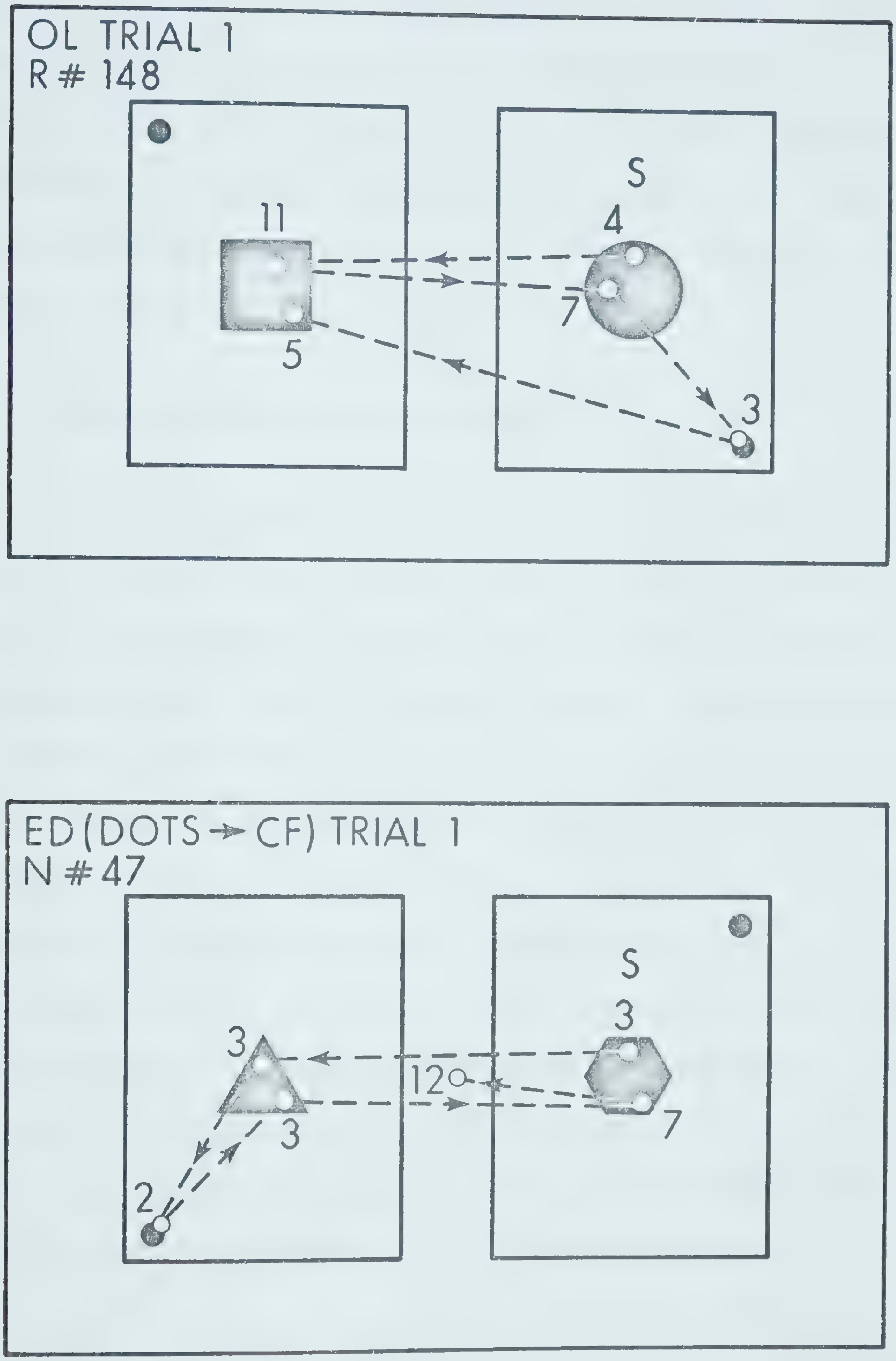
ID Shift

No difference between Ns and Rs was predicted from attention theory in frames on relevant and irrelevant dimensions in ID shift. Furthermore, no difference was found between Ns and Rs in looking at these dimensions in OL (See Hypotheses 4.1 and 4.2, above). Accordingly, it is surprising that in ID shift, Rs should have more frames on relevant dimension than Ns (Hypothesis 6.1). Although this result is contrary to expectation, it does indicate a relative increase in the attending response of Rs when there is positive transfer. Nevertheless, a concomitant decrease in attending to the irrelevant dimension was not found (Hypothesis 6.2). There was no difference between Ns and Rs in frames on irrelevant dimension in ID shift.

The unscorable frames variable was not affected by positive transfer, as predicted; Ns exhibited fewer unscorable frames than Rs in ID shift (Hypothesis 6.3).

ED Shift

The predicted differences between Ns and Rs in ED shift on eye



Eye Movements of Two Subjects for Thirty Frames in Separate

Discrimination Task Trials

Figure 5

movement patterns were not found, except for unscorable frames where Ns once again had fewer unscorable frames than Rs (Hypothesis 6.6). Ns and Rs did not differ in frames on relevant dimension (Hypothesis 6.4) nor irrelevant dimension (Hypothesis 6.5) in ED shift. The results for frames on the two dimensions appear to be in keeping with the lack of difference between Ns and Rs in OL.

IV. Comparison of Eye-shift Activity

The two different eye-shift measures investigated in this study might be considered to reflect different perceptual processes. On the one hand, total shifts may reflect general perceptual activity, or the overall perceptual "style" of the individual, and may remain constant for the individual, irrespective of what is viewed. On the other hand, left-right shifts might reflect a more selective kind of perceptual activity, and be related to the type of stimulus presented, regardless of personality or individual difference variables.

No difference in total eye-shifts was found between Ns and Rs in OL (Hypothesis 7.1), ED shift (Hypothesis 7.4), and the CF condition of ID shift, but Rs exhibited more total eye-shifts in the Dots condition of ID shift (Hypothesis 7.3). It would thus seem that, generally speaking, overall perceptual activity is independent of intelligence level.

On the other hand, selective perceptual activity did appear to vary with intelligence, since Rs had more left-right shifts than Ns in both OL (Hypothesis 7.1) and ID shift (Hypothesis 7.3). In that higher IQ

subjects might be expected to make more selective comparisons than lower IQ subjects, these results appear surprising. A possible explanation might be that once Ns solved the task, they no longer searched the stimulus field. However, this explanation does not appear warranted since total shift activity was generally the same for both groups of subjects. Perhaps, then, the perceptual activity of Ns was characterized by movements other than from one stimulus box to the other. There was no difference in left-right shifts between Ns and Rs in ED shift (Hypothesis 7.4) nor were there any differences in eye-shift activity, total or left-right, between ID and ED shifts (Hypothesis 7.2).

In summary, there is no evidence from the eye movement data for a retardate attention deficit, within the structure of Zeaman and House attention theory. Ns do not look more at the relevant dimension and less at the irrelevant dimension initially than Rs. Nevertheless, Rs do exhibit a constant, artifactual kind of inattention, as inferred from their greater tendency towards unscorable frames. Furthermore, there is only minimal evidence of dimensional transfer to ID and ED shifts. The subjects may have looked more at the relevant dimension and less at the irrelevant dimension in ID shift as compared with ED shift, thereby suggesting that there may have been transfer of positive and/or negative observing response. Additionally, there was no evidence for the N and R observing responses in ID and ED shifts predicted by attention theory. Contrary to prediction, Rs looked at the relevant dimension more in ID shift than Ns, while in ED shift Ns and Rs did not differ in attending to the relevant and irrelevant dimensions. On the

exploratory variables, Ns and Rs were found to have similar total eye-shift scores, but Rs showed more selective (left-right) shifts in OL and ID shift than Ns. Dimensional salience seemed to affect the looking behavior of both Ns and Rs, for all subjects looked more at the CF stimuli than the Dots, regardless of whether these constituted the relevant or the irrelevant dimension.

Additional Eye Movement Data

In the course of eye movement data collection, it became apparent that some subjects, instead of looking at the stimulus elements for the full filming time of five seconds, were looking at the stimuli initially, but then were gazing directly at the center of the stimulus slide, seemingly in anticipation of trial termination. Recent studies have indicated that perceptual decentration parallels development of particular cognitive abilities in normal and educable mentally retarded children (O'Bryan and Boersma, 1970; and Wilton and Boersma, 1970). Since the two samples in the present study differed widely in IQ and consequently in cognitive ability, it was felt that frames on center might provide some useful insight into N and R discrimination shift learning performance.

Operationally, frames on center were defined as the number of frames coded for the center of the stimulus field; that is, the corneal reflection was on neither the left nor the right box (See Appendix C). The possible range of scores was from 0 to 240 (30 x 8) for each of OL and SL. This represented the number of frames on center in the first

thirty frames (three seconds) of stimulus viewing for eight trials.

Preliminary analyses indicated no effect of dimensional salience on frames on center, so the data were collapsed over CF and Dots conditions. The data were analyzed by means of Welch's *t*' tests.

I. Comparison of Frames on Center for Ns and Rs in OL, ID Shift and ED Shift

From Table 26 it may be seen that frames on center were greater for Ns than for Rs in OL, ID shift and ED shift. Accordingly, it seems clear that regardless of discrimination shift task, Ns had a greater tendency to look away from the stimulus boxes and fixate on the center than Rs.

Two possible interpretations of these results are suggested. To begin with, frames on center might indicate a tendency to quick appraisal of the stimulus field. Since all subjects were given the same amount of viewing time on a trial before being asked for their response choice, quick-appraising subjects may have searched briefly initially for the correct stimulus and then fixed their gaze on the center while waiting for trial termination. They may have looked at the center rather than elsewhere because eye camera calibration required looking at the center of the calibration slide. It is not surprising that the normal sample with their higher IQs should have exhibited looking behavior more characteristic of quick appraisal than Rs.

Secondly, frames on center might indicate a cognitive ability to look away from the stimulus which is responded to, in line with the findings of O'Bryan and Boersma (1970) and Wilton and Boersma (1970) that lower levels of cognitive development (non-conservation) are not

Table 26

Mean Scores (M), Standard Deviations (sd), Numbers of Subjects (n), Analyses and Results for Frames on Center

Task	Subjects	M	sd	n	t'	Adj. df	P	Results
OL	Normals	16.3	23.2	64				
	Retardates	8.7	8.7	64	2.5	80.2	0.02	N > R
ID	Normals	40.9	56.3	28				
	Retardates	10.4	9.2	20	2.8	29.0	0.01	N > R
ED	Normals	17.7	30.3	26				
	Retardates	4.8	4.2	15	2.1	26.6	0.04	N > R
ID	All	28.2	35.6	48				
ED	All	13.0	19.7	41	2.6	61.3	0.03	ID > ED

characterized by "decentring" of eye movements from the correct stimulus. It would be expected that Ns rather than Rs would exhibit the perceptual patterns associated with higher cognitive development.

II. Comparison of Frames on Center in ID and ED Shifts

From Table 26 it may also be seen that in the comparison across discrimination shift tasks, ID shift was characterized by a greater number of frames on center than ED shift. It thus appears that the task at hand is a factor affecting center fixations, with the positive transfer situation (ID shift) being more productive of center fixations than the negative transfer situation (ED shift). This result suggests that less searching of the stimulus field was necessary in order to solve the ID shift task than the ED shift task. That the ID task was indeed easier than the ED task for all subjects, Ns and Rs, was seen above in the performance data.

CHAPTER 7

INTEGRATION AND CONCLUSIONS

It was the intent of the present study to investigate attending responses of normal and educable mentally retarded children in discrimination shift learning. According to Zeaman and House (1963), retarded children have an attention deficit when compared to normal children. They are said to take longer to attend to the relevant dimension in a discrimination learning task. Consequently, they are slower in learning the task than normal children. However, as Mostofsky (1968) and Wischner (1967) have pointed out, there is circularity of argument here, since no objective dependent variable has been employed to measure attending response. It was suggested that eye movement measures (Muir, 1971) might be useful in providing such an objective measure.

Accordingly, two separate kinds of data were gathered while subjects aged nine to twelve years solved two-choice visual discrimination tasks: performance data and eye movement data. For the former, a record was kept of the instrumental responses on each trial, and the last error preceding the criterial run noted. Those subjects who learned the original task (OL) were then transferred to a shift condition (SL). Again the last error was noted. A mean trial of last error for both the OL and the SL tasks was calculated for each subject group. Additionally, the percentage of learners was determined for each group. These two measures, mean trial of last error and percentage of learners, which were based on the subjects' performance in the discrimination

tasks, were considered to reflect a dimensional identification aspect of attending response (Goodwin and Lawrence, 1955).

For the eye movement data, a filmed record was made of the subjects' eye movements over the task stimuli for the first eight trials in OL and the first eight trials in SL, with the exception of subjects in the control shift (CS). These data were considered representative of an overt observing response aspect of attending response (Wyckoff, 1952). The collection of eye movement data concomitantly with performance data was intended to provide an objective overt observing response variable along with the type of covert observing response variable commonly used in the Zeaman and House studies.

All together, six different eye movement variables were analyzed: frames on relevant dimension, frames on irrelevant dimension, unscorable frames, total shifts, left-right shifts, and center fixations. Of these, frames on relevant dimension and frames on irrelevant dimension had the most obvious bearing on the issue of attention deficit.

Performance and Eye Movement Comparisons

I. N and R Comparisons in OL

In the analyses of the performance data, evidence for a retardate attention deficit was found in OL when only one of the two dimensions formed the relevant dimension, namely Dots. When the other dimension, CF, was relevant to task solution, no difference in learning rate was found between Ns and Rs. Thus a difficulty variable was introduced into the discrimination task, with Rs learning more slowly than Ns

(in other words, exhibiting an attention deficit) only when the difficult dimension was relevant. It appears that the occurrence of retardate attention deficit in the Zeaman and House model may be limited to difficult dimensions.

In the analyses of eye movement data, no difference in frames on relevant and irrelevant dimensions in OL was found between Ns and Rs. Ns did not look more at the relevant dimension nor less at the irrelevant dimension than Rs in the initial task. It was thus concluded that to the extent that frames on relevant and irrelevant dimensions reflect dimensional attending responses, independent overt evidence for a retardate attention deficit in OL has not been found in this study.

Nevertheless, there were fewer unscorable frames for Ns than for Rs in all conditions of OL, suggesting that Rs may be characterized by a general form of inattention, regardless of the task at hand. Similar results on unscorable data were obtained by Muir (1971).

In the OL task, all subjects looked more at the CF stimuli than at the Dots, regardless of whether these were relevant to solution or not. Clearly the CF dimension had greater salience than the Dots dimension. It was noted above that when CF were relevant to solution, there was no difference between Ns and Rs in OL task performance. It would thus appear that dimensional salience and learning task difficulty are functionally related.

II. Comparisons across Shift Tasks

Zeaman and House theory predicts that since ID shift arranges for positive transfer of attending response, ED shift arranges for negative

transfer of attending response, and CS arranges for neither positive nor negative attending response, the probability of attending to the relevant dimension should be highest at the commencement of ID shift and lowest at the commencement of ED shift, when ID shift, ED shift and CS are compared.

For the performance data this implies that ID shift should be easier to learn than either CS or ED shift, while CS should be easier to learn than ED shift. It was found that the mean trial of last error was ordered such that ID shift $<$ CS $<$ ED shift for both the easy and the difficult stimulus conditions, while the percentage of learners was ordered such that ID shift $>$ CS $>$ ED shift for the easy (CF) condition only. Generally speaking, then, it would appear that there was evidence of covert positive transfer on ID shift and covert negative transfer on ED shift, as anticipated from attention theory.

Since CS was not filmed, eye movement comparisons across shifts involved ID and ED shifts only. From attention theory, it was predicted that subjects should look more at the relevant dimension and less at the irrelevant dimension during ID shift than ED shift. This prediction was borne out for the easy (CF) condition only. In the difficult (Dots) condition, there was no difference in looking at the relevant and irrelevant dimension in ID and ED shifts. Because the results differed for the two stimulus conditions, it would appear that dimensional salience effect interacted with transfer effect to yield different eye movement patterns for the CF and Dots conditions.

In the CF condition, since the results concurred with the

predictions made from attention theory, it could be inferred that positive transfer was involved in ID shift and/or negative transfer was involved in ED shift. Since there were no eye movement data for CS, it is not possible to isolate the effects of positive and negative observing response transfer independently of each other. Nevertheless, there is another plausible explanation for the CF condition results. It has been shown in this study that the CF stimuli have greater salience than the Dots stimuli for all subjects. In the CF condition, since CF were relevant in ID shift while Dots were relevant in ED shift, the finding of more frames on the relevant dimension and fewer frames on the irrelevant dimension in ID shift could be attributable simply to the subjects' tendency to look more at CF than at Dots. Thus the results of the CF condition comparison of eye movements in ID and ED shifts do not provide unchallengeable support for observing response transfer.

In the Dots condition, however, the evidence for overt attending response transfer may be somewhat less equivocal. In the Dots condition, Dots were relevant in ID shift, while CF were relevant in ED shift. On the basis of predictions from dimensional salience effect, it would be expected that the relevant dimension would be looked at more, and the irrelevant dimension looked at less, in ED shift (CF stimuli) as compared to ID shift (Dots stimuli). On the basis of predictions from attention theory, it would be expected that ID shift (positive transfer) would have more looking at the relevant dimension and less looking at the irrelevant dimension than ED shift (negative transfer). The predictions from attention theory are thus seen to be in opposition to

those made from dimensional salience effect. The results, however, indicate no difference in observing the two dimensions in ID and ED shifts. It thus appears that the Dots condition results cannot be attributable exclusively either to dimensional salience effect or observing response transfer. On the other hand, these results may be inferred if it is assumed that dimensional salience effect and attending response transfer interact. In ID shift, positive transfer effect may augment observing response to the difficult dimension. Conversely, in ED shift, negative transfer effect may decrement attending to the salient dimension. It thus appears that positive and/or negative transfer effect may have been present in eye movement patterns across discrimination shift tasks. Accordingly, it was concluded that some independent evidence for transfer of positive and/or negative attending response was found in this study.

III. N and R Comparisons in ID Shift, ED Shift and CS

ID Shift

From attention theory, it was postulated that regardless of the intelligence of subjects, once learning has occurred, the probability of attending to the relevant dimension is high, and furthermore, is capable of transfer. At the commencement of ID shift, no difference in attending response between Ns and Rs would be anticipated.

In the performance data, no difference was found between Ns and Rs on ID shift in all conditions, as expected. Nevertheless, since no difference was found between Ns and Rs in the CF condition of OL, equality of performance on ID shift in that condition could not be

considered supportive of attention theory. However, in the Dots condition of OL, Ns learned more quickly than Rs; consequently, the equal performance of Ns and Rs observed in ID shift could suggest that Rs had learned to attend to the relevant dimension in OL, and that this attending response had been transferred. In other words, the initial attention deficit of Rs observed in OL was eradicated in ID shift on the difficult dimension. For this to have happened it is inferred that the high probability of attending to the relevant dimension at the conclusion of OL transferred to ID shift.

With respect to the eye movement variables, no difference between Ns and Rs was predicted in looking at the relevant and irrelevant dimensions in ID shift. Nevertheless, Ns were found to look less at the relevant dimension, regardless of whether the easy or difficult stimulus conditions were involved, than Rs in ID shift. It thus appears that, relative to Ns, there was an increase in the attending response of Rs to the relevant dimension with positive transfer. Since Zeaman and House assume a deficit in attending response for Rs in OL, with an increase to equality with Ns in ID shift, the observed increase for Rs does not take the form predicted by the model.

No difference was found between Ns and Rs in looking at the irrelevant dimension in ID shift. On the unscorable frames variable, Ns again showed less general inattention than Rs.

<u>ED Shift</u>

From the assumptions of attention theory, it was hypothesized that intelligence would make a difference in learning ED shift.

Although the probability of attending to the dimension which becomes relevant in ED shift cannot be determined with any certainty from the attending response probabilities in OL, Ns would be expected to have the greater probability of attending to this dimension than Rs because in a new task they are more likely to select out the important variables than Rs.

On the performance data, it was anticipated that Ns would find the ED task easier than Rs. It was found that Ns and Rs did not differ in either mean trial of last error or percentage of learners in ED shift for both the CF and Dots conditions. Thus there was no support for the assumption that Ns would learn ED shift more easily than Rs.

In terms of eye movements, it was anticipated that Ns would fixate more on the relevant dimension and less on the irrelevant dimension than Rs in ED shift. However, no differences in fixation on the relevant and irrelevant dimensions between Ns and Rs was found. It thus appeared that no objective evidence was found to support the contention that Ns are more likely to attend to the important dimensions in a new shift task than Rs.

As before, Ns were found to have fewer unscorable frames than Rs in ED shift, again suggesting a difference between Ns and Rs on a general inattention factor.

Control Shift

Since the CS is a new task, involving dimensions different from those in OL, it was predicted that Ns would have a greater probability of attending to the relevant dimension in CS than Rs. On the

performance data, Ns were indeed found to have a lower mean trial of last error and a higher percentage of learners than Rs in the CF condition, as anticipated, but no difference between Ns and Rs was found in the Dots condition. There were no eye movement data for CS.

When the performance results for CS are compared with those for OL, a discrepancy is noted with respect to dimensional salience effect. Whereas in OL no difference was found between Ns and Rs in the CF condition, in CS no difference was found in the Dots condition. Since CS subjects were not filmed in the process of learning the experimental tasks, the filming procedure may have interacted with dimension difficulty. For instance, the physical restrictions required for filming may have been more distracting for Rs than for Ns.

IV. Additional Eye Movement Patterns

In terms of eye-shift activity, Ns and Rs were found to differ very little on total eye-shifts, which may represent a general, overall kind of perceptual activity. From this it was inferred that total eye-shift activity was independent of intelligence level. However, left-right shifts, which may represent a selective perceptual activity, were found to be more pronounced for Rs than for Ns in OL and ID shift. In that Ns, having higher IQs and consequently greater cognitive abilities than their CA matched Rs, would have been expected to exhibit more selective shifts, this result was surprising, and could bear further investigation. No difference was found between ID and ED shifts on either total or left-right eye-shifts.

In terms of frames on center, Ns exhibited a greater tendency

than Rs to look away from the stimuli and at the informationless center on OL, ID shift and ED shift. This would tend to suggest that Ns were capable of indicating an instrumental response without continuous looking at the appropriate stimulus. Frames on center were also seen to be influenced by task conditions, since there were more frames on center in the positive transfer situation (ID shift) than in the negative transfer situation (ED shift). From this it might be inferred that subjects needed less viewing time to decide on a response choice in ID shift than in ED shift.

Neither the eye-shift patterns nor the frames on center variable appears to have direct relevance to observing response transfer as postulated by attention theory. Nevertheless, these eye movement variables do indicate major differences in the looking behaviors of normal and educable mentally retarded children. It is suggested that such overt differences might reflect differences in central processing of incoming stimuli between Ns and Rs.

Summary of Performance and Eye Movement Comparisons

To sum up the results of analyses directly concerning Zeaman and House attention theory, it seems that within the framework of a covert dimensional identification interpretation, based on instrumental response performance, and an overt observing response interpretation, based on eye movement patterns, evidence has been cited to support the following aspects of the theory:

I. Retardate Attention Deficit

On the performance data, this deficit was evident on difficult tasks only. However, Ns and Rs had similar eye movement patterns in OL. In other words, no objective observable evidence was found for a retardate attention deficit. Nevertheless, Rs were found to exhibit more of a gross form of inattention than Ns in their eye movements.

II. Transfer of Attending Response

Positive and negative transfer of attending response was evident on the performance data with the shift tasks ordered such that ID shift $<$ CS $<$ ED shift, in terms of ease of learning. From the eye movement data, there was some support for transfer of positive and/or negative dimensional attending response, with ID shift possibly characterized by more looking at the relevant dimension and less looking at the irrelevant dimension than ED shift.

III. Elimination of Retardate Attention Deficit

Once Rs learned a difficult task, they performed as well as Ns on both positive and negative transfer tasks. The Rs, however, looked at the relevant dimension more than Ns when positive transfer was arranged. Rather than moving from initial deficit to ID shift equality with Ns on eye movements, as attention theory postulates, Rs moved from initial equality to ID shift superiority over Ns.

In general, then, it may be seen that the results of this study were generally compatible with the predictions of Zeaman and House attention theory when instrumental response performance formed the

dependent variables, but not when eye movements formed the dependent variables.

Limitations of the Study

The conclusions concerning attending response reached in this study must be qualified by the following limitations:

(1) Slamecka's (1968) total change design was used in order to assess dimensional transfer without instrumental response interference. Nevertheless, because the two dimensions involved in the discrimination task were not of equal difficulty or salience, positive and negative transfer effects could not be clearly evaluated. This was particularly true of the eye movement data.

(2) The adoption of a non-correction testing procedure along with a thirty trial maximum for each discrimination task, shift or original, caused a number of subjects to be eliminated from the shift conditions. This decrement, combined with the necessity of running analyses separately for the two dimensions, meant that for some of the analyses, small numbers of subjects were involved. In particular, there were less than five retarded subjects in the Dots condition of ED shift, and in all the conditions of CS. Analyses involving these subjects were run for comparative purposes, but the results were advisedly tentative.

(3) All of the eye movement variables were based on the first eight trials of both OL and SL for all of the subjects included in a particular condition. No attempt was made to segregate subjects

according to commencement of criterial run. Consequently, while some subjects may have solved the task within the first eight trials, others may have still been searching for a solution. It was suggested that perhaps such criterial diversity may have obscured real differences in the attending response of the two sample groups, or perhaps even in comparisons across shift tasks. Nevertheless, preliminary analyses of eye movements in each of the first two trials of each task, when all of the subjects were still theoretically evaluating the stimuli, produced results compatible with the analyses for the combined eight trials.

(4) During the discrimination tasks, the subjects' field of vision was narrowed by apparatus and lighting to the translucent screen on which stimuli were presented. The suggestion was made that such restrictions would be of less benefit to Ns who are said to channel their energies as required anyway, than to Rs who are considered to be easily distractible from the task at hand. Such limitation of competing stimulation from the environment might constitute an atypical discrimination learning situation and consequently obscure ordinary normal-retardate differences. Nevertheless, on unscorable frames, Rs were found to be more subject to gross distractiblity than Ns in this study.

(5) While the present study was carried out within the general framework of attention theory, several boundary conditions of the theory were not met. Zeaman and House adopt a correction procedure to ensure learning in discrimination tasks, but here a non-correction procedure was used in order to avoid obscuring or confounding of the observing responses as measured by eye movements, particularly in the initial trials of OL and SL. Additionally, Zeaman and House use only positive

reinforcement in their learning investigations, whereas in this study both positive reinforcement ("correct") and punishment ("wrong") were employed, so as to facilitate learning as quickly as possible within the 30 trial maximum on each task. Furthermore, Zeaman and House match their normal and retardate subjects on mental age, while here subjects were matched on chronological age, in order to investigate developmental aspects of observing response.

Implications

Although the instrumental response performance of subjects in this study has generally followed the outlines of attention theory, the attempt to validate the theory by providing an objective measure of attending response has met with limited success. That Ns and Rs do not differ in looking behavior involving relevant and irrelevant dimensions in the initial discrimination task raises serious doubts concerning the Zeaman and House contention that Ns have a greater tendency to attend to the relevant dimension initially than Rs. While it may be argued that looking at the relevant and irrelevant dimensions does not adequately reflect attending response, it may be counterargued that no other independent variables seem to reflect it either. This leaves attention theory still open to the criticisms raised by Mostofsky (1968) and Wischner (1967).

Nevertheless, some eye movement results appear fruitful apart from attention theory considerations, and could have significance for further research involving normal and retarded samples. The finding that Rs exhibit more relevant looking behavior than Ns on ID shift, for

example, raises questions concerning retardate functioning in a positive transfer task. Similarly the findings that Rs exhibit more selective eye-shifts than Ns raises questions concerning the relative efficiency of information processing by Ns and Rs.

Mackworth and Bruner (1970) have shown that children are less efficient in their visual search of a stimulus field than adults. By analogy, since the Rs in this study were of lower mental age than the Ns, it may be anticipated that their search strategies would be less effective than that of Ns. Such ineffective strategies may reflect a deficiency in information processing of incoming stimuli. Paradoxically, in this study Rs appeared to employ better search strategies than Ns. Further research into the relationship between search strategies and information processing would appear warranted.

The issue of dimensional salience appears to have important ramifications for retardate learning as well, since tasks involving very obvious or eye-catching stimuli are solved as easily by Rs as by Ns. This would suggest that perceptual factors relating to the visual distinctiveness of stimuli are important influences on learning. Such distinctiveness may aid learning by simplifying information processing. Further investigations to clarify the relationship between dimensional salience and information processing by Ns and Rs would appear to be indicated.

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APPENDIX A

LABORATORY PROCEDURE AND TAPED INSTRUCTIONS

LABORATORY PROCEDURE AND TAPED INSTRUCTIONS

1. S enters lab
2. Tour of lab and explanation of equipment
3. S is seated in chair; chair adjusted; rough alignment of eye camera
4. Bite bar explained; S fitted with bite bar; S given "Smarties" or "Sweetarts" (No bite bar for control Ss)
5. Training for button press (no slides; on tape; verbal reinforcement)

   "There is a button for you to press with each hand. Now press the button with THIS hand. (E indicates S's left hand; E says 'Good') Now push the button with the other hand. (E: 'Good') Push only one button at a time. Now try that again. Push the button with THIS hand (left hand indicated). Now the other one." (E: 'Good')

6. Training for button press (slides 1, 2, 3 & 4 synchronized with tape; verbal reinforcement)

   "Now look at these pictures on the screen. There is a sun and a moon. Keep looking at them until I tell you what to do. (Pause 5 sec.) Push the button which is on the same side as the sun. Push the button only once. (E: 'Good') Now I will show you some more pictures. Look at them carefully until I tell you what to do. (Slide # 2 for 5 sec.) Push the button which is on the same side as the sun is now. (E: 'Good') Now look at these pictures until I tell you what to do. (Slide # 3 for 5 sec.) Push the button which is on the same side as the moon. (E: 'Good') Now look at these pictures. (Slide # 4 for 5 sec.) Push the button which is on the same side as the moon." (E: 'Good')

7. Calibration of eye camera (S on bite bar; verbal instructions)

8. Task instructions (on tape; S off bite bar; screen blank)

> "Now we are going to play a game. On the screen there will be two pictures. You will notice that each of these is different. One of them will always be the correct one, and I will tell you if the one you choose is right or wrong. Now what you have to do is learn which one is always the correct one. This is the way you do it. Look at the two pictures very carefully and decide which one you think is the correct one. I will tell you whether the one you choose is right or wrong. Remember to look at both pictures very carefully, and to push the button when I tell you. Do not come off the bite bar until you are told to do so." (last sentence deleted for control Ss)

Filmed conditions (A1 to D4)

OL starts with slide # 5 (calibration slide)

SL starts with slide # 43 (calibration slide)

Control conditions (E1 to H4)

OL starts with slide # 5 (trial # 1)

SL starts with slide # 35 (trial # 1)

S off bite bar on non-filmed trials

APPENDIX B

DISCRIMINATION SHIFT RESPONSE SCORE SHEET

Score Sheet # 1 Name ....

Tray A: circle & hexagon
Tray B: circle & lower left dot
Tray C: upper left dot & lower left dot
Tray D: upper left dot & hexagon
Tray E: circle & large
Tray F: circle & 3
Tray G: upper left dot & large
Tray H: upper left dot & 3

OL cue			SL cue		
1	L	...	1	L	...
2	L	...	2	L	...
3	R	...	3	R	...
4	L	...	4	R	...
5	R	...	5	L	...
6	R	...	6	R	...
7	L	...	7	R	...
8	L	...	8	L	...
9	R	...	9	L	...
10	R	...	10	R	...
11	L	...	11	L	...
12	R	...	12	R	...
13	L	...	13	L	...
14	R	...	14	R	...
15	R	...	15	R	...
16	L	...	16	L	...
17	L	...	17	L	...
18	R	...	18	L	...
19	L	...	19	R	...
20	R	...	20	R	...
21	R	...	21	L	...
22	L	...	22	R	...
23	L	...	23	R	...
24	R	...	24	L	...
25	R	...	25	L	...
26	R	...	26	R	...
27	L	...	27	L	...
28	L	...	28	L	...
29	R	...	29	R	...
30	L	...	30	R	...

APPENDIX C

NUMERICAL CODE FOR SCORING EYE MOVEMENT DATA AND

GUIDELINES FOR UNSCORABLE FRAMES

NUMERICAL CODE FOR SCORING EYE MOVEMENT DATA

1. eye spot is on relevant dimension, correct cue
2. eye spot is on relevant dimension, wrong cue
3. eye spot is on irrelevant dimension, cue is in correct box
4. eye spot is on irrelevant dimension, cue is in wrong box
5. eye spot is on correct box, but not on any cue
6. eye spot is on wrong box, but not on any cue
7. eye spot is on center, not on either box
8. eye spot is blurred, missing or indefinable (unscorable)
9. total shifts of eye spot, not counting unscorable frames (8)
10. left-right shifts of eye spot, from one box or cues within it to the other box or cues within it, for example, from (2) to (3), not counting center fixations (7) and unscorable frames (8)

GUIDELINES FOR UNSCORABLE FRAMES

1. If there is a single unscorable frame, it is scored as the preceding frame.
2. If there are two consecutive unscorable frames, the first is scored as the immediately preceding scorable frame, and the second is scored as the immediately following scorable frame.
3. If there are three or more consecutive unscorable frames, then they are scored (8).

APPENDIX D

EYE MOVEMENT SCORE SHEETS FOR RAW DATA AND SUMMATIONS

Name ______________________________ Code ______ Condition ______

1 .... 2 ....

3 .... 4 ....

5 .... 6 ....

7 .... 8 ....

	1	2	3	4	5	6	7	8
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
Total								

	1	2	3	4	5	6	7	8
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48								
49								
50								
Total								

Total Trial _____

1	2	3	4	5	6	7	8

S chose _____

It was _____

Name ______________ Code ________ Condition ________

Trial # ________

	1	2	3	4	5	6	7	8	9	10
Frames 1 - 10										
Frames 11 - 20										
Frames 21 - 30										
Frames 31 - 40										
Frames 41 - 50										
Total 1 - 30										

Trial # ________

	1	2	3	4	5	6	7	8	9	10
Frames 1 - 10										
Frames 11 - 20										
Frames 21 - 30										
Frames 31 - 40										
Frames 41 - 50										
Total 1 - 30										